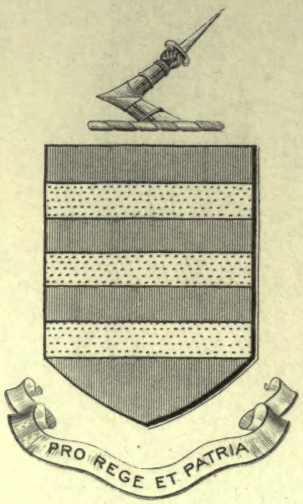
OPERATIVE SURGERY
WITH
SURGICAL ANATOMY
& SURFACE MARKINGS

D. C. L. Fitzwilliams



A MANUAL OF OPERATIVE SURGERY

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BY

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PREFACE

THIS text-book on operative surgery is not written to be read by surgeons. A master of the art needs no handbook. It is written for the instruction of the apprentice and to help the journeyman craftsman of our profession. For these two classes of individuals different objects must be kept in view. The most elementary principles and actual groundwork is needed for the former, while for the latter much of the groundwork has little interest and may be omitted.

To the student, the teaching of how to apply a ligature correctly to an artery is of the highest importance as an exercise; for a busy practitioner it would be waste of time. On the other hand, the steps of the operation for the relief of a strangulated hernia have for the student an examination interest only; while to the practitioner the recalling of these may be the means of saving a life.

The difficulty is to include the wants of both these classes in the compass of a volume of handy size; this difficulty is increased when, as here, the main points in surgical and surface anatomy are added.

The elementary teaching here embodied is derived from that received both in Edinburgh and London, crystallized by a long experience of coaching for the higher examinations. It follows closely the method of instruction now given in the operative surgery classes conducted at St. Mary's Hospital.

The old nomenclature has been kept, as, although the medical profession in this country is prepared to adopt the advances made in the principles of the Basle nomenclature, it appears unwilling to assimilate the manifest absurdities which at present accompany them. We are glad to say that the Anatomical Society of Great Britain have at last taken steps to call a meeting of English-speaking Anatomists from all parts of the world, in order to revise the nomenclature. At present, therefore, it seems undesirable to promulgate names which may possibly be deleted during the next two years.

My best thanks are due to M. E. for help with the illustrations, without whose aid many could not have been drawn. I am indebted to Mr. Jones for the drawings from which Figs. 27, 58, and 59 are taken. The illustrations which are borrowed are, I hope, all acknowledged, and the kindness of the authors in allowing their use is fully appreciated.

The careful correction of the proofs I owe entirely to the good nature of my colleague, Mr. C. A. Pannett. The many deficiencies, omissions and errors I have to acknowledge as my own.

D. C. L. F.

31, Grosvenor Street,
6th July, 1913.

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OPERATIVE SURGERY, SURGICAL ANATOMY, Etc

CHAPTER I

General Considerations

Examination of the patient—Preparation for the operation—Sepsis, antisepsis, and asepsis—General principles.

EXAMINATION OF THE PATIENT

Conditions which have an effect on Operations

Although an operation is planned to prevent or relieve disease or its effects, it may of itself, if lightly and inadvisedly undertaken, be a source of grave danger to the patient. The course of even a small operation for the relief of some trivial ailment may be profoundly modified by the existence of disease in some other part of the body, a part which the surgeon has not taken the trouble to examine, or has done so only in a superficial manner. For this reason no patient should be submitted to an avoidable operation without first having been thoroughly examined as to the state of his general health and, as far as it can be ascertained, of his individual viscera also. The opening of abscesses, the relief of tension and associated pain are often performed in spite of all contra-indications, and are not included under the term avoidable operations.

Emergency operations have to be done in spite of everything, but even their extent is influenced by the knowledge of existing disease. Atheroma, for instance, would compel one to amputate at a higher level for a crushed foot than would otherwise be necessary, while hæmophilia would forbid one to extract a carious tooth.

It is of importance therefore to glance first at the general conditions which affect operations and then to take up the diseases

of the different systems. Not only must the local conditions be taken into account, but the general considerations, the risks, and the benefit likely to accrue; these must all be weighed before an operation is urged.

General conditions

Age.—The extremes of life, whether old age or infancy, may be said to bear operations badly. Speaking of amputations, Sir Frederick Treves remarks: "The mortality is lowest between the ages of five and fifteen, and these certainly give the best results from operations of almost every kind. After fifteen the death rate begins steadily but slowly to increase. The variation between the whole period from twenty to forty is certainly not considerable; but the risk of death after operation is twice as great in patients between those ages as it is in individuals under twenty. In patients over forty the mortality is nearly three times in excess of the rate observed in patients under twenty. The increase in risk of death between fifty and seventy is very rapid." These statistics were formed from the operations performed before the era of antiseptics, and probably deal most accurately with the course of septic wounds, but they may be taken also as a good, if severe, guide for the first intention wounds of the present day.

Sex.—Over a large number of cases it is found that women bear operation slightly better than men. This is probably due to the fact that the average woman lives a quieter and more temperate life than the average man. Women are as a rule more patient of restraint.

Mode of Life.—The individual who has led what is termed a healthy life is a fitter subject for operation than one who has led an unhealthy one. A properly regulated ratio between exercise and work, habits which have been regular and abstemious, freedom from worry and the anxiety of business details, observance of early hours, a life spent largely in the pure air of the country, are all valuable assets when the bed of sickness has to be endured. While an existence which has been all work and no play, irregular habits, intemperance, and late hours, the harassing details of a trying business conducted in the vitiated atmosphere of a large town, ill equips the individual for a serious operation. The fine strong man, full of vigour, leading a strenuous life, taking a good deal of exercise is not always the one to prove a good patient when suddenly laid up as the result of a smash. His system is taken unawares, the muscular action on which his health depended is

suddenly arrested, and the elimination of waste products at once becomes imperfect. Resignation and patience are often not strong points with such an one. His nervous system takes unkindly to enforced quietude. He worries over details which would not trouble him in health. Possibly he has a different mode of life to look forward to owing to the injury, and perhaps loss of a limb.

Prolonged ill-health, on the other hand, often has not the ill effect on operation that one would at first sight imagine. The patient has been accustomed by his complaint to the invalid state, his mode of life receives no sudden change, and the lesson of resignation and patience has been already learned. His nervous system contemplates the operation as a means of relief from pain and a road to a more congenial existence. Even amputation may be regarded as a welcome means of being rid of a useless limb, which has rendered his life a burden both to himself and his relations.

Acute Fevers.—No operation should be performed if possible on those suffering from acute fevers, as wounds made in such people are very liable to suppurate and then heal slowly. In erysipelas incisions are called for to let out pus or limit the spread of cellulitis. In those who have previously been exposed to infection, wounds either inflicted by the surgeon or sustained in other ways are liable to determine the onset of scarlatina; such wounds invariably suppurate.

Hæmophilia.—This affection contra-indicates even the simplest breach of surface if this can be avoided. Extraction of a tooth or accidental biting of the tongue has frequently caused death from hæmorrhage in boys. Females transmit but rarely suffer from the disease. In families where hæmophilic tendencies are known to exist the coagulability of the blood should be tested before all operations. The coagulability may be raised by a milk diet and the administration of calcium lactate and calcium chloride.

Scurvy.—This may well be ranked with hæmophilia, as the coagulability of the blood is far below the normal, as is evidenced by the submucous and subcutaneous hæmorrhages. The general health at the same time has lowered the resistance of the tissues to organisms, to such an extent, that the wounds are very liable to suppurate.

Alcoholism.—This is a condition which renders the patient eminently unsuited for operative treatment. Alcohol in excess is often quite well borne by people leading an active life, but when deprived of exercise and confined to bed, such people immediately

show the pernicious effect of the habit. If suddenly struck down from any cause, delirium tremens is very liable to set in during the first week, and many die from the actual effects of alcohol, combined with the confinement of the sick room. Even when the results are not so serious, the patient is intolerant of restraint, restless, and irritable; the appetite is capricious, the digestion is upset, the bowels are sluggish and will not react to drugs. The local conditions are just as bad, for the tissues are peculiarly liable to septic invasion, and the results of operations are frequently disastrous from this cause.

Obesity.—The very fat are often unsuitable patients; especially is this the case if they are advanced in years. But it is not always the mere presence of fat which is so disadvantageous, it is the cause, over-eating, want of exercise, alcohol, of which obesity is a mere symptom, or the associated conditions of fatty heart or asthma, which give rise to anxiety. The very weight of the subcutaneous tissue may put a greater strain on the sutures than the skin will bear, and they cut out, for the thick fat below the skin is ill adapted to resist tension.

Tuberculosis.—Patients suffering from tubercular lesions needing operation, as a rule stand the operation well. In the majority of cases the disease has been of long standing, many methods of treatment have been tried and failed, and the patient has gone through much pain and distress before a radical operation is offered to him, as a chance of freedom from the scource of all his trouble. No sooner has the operation been carried out than the general health begins to improve; partly, it may be, on account of the freedom from pain, and partly because the focus of disease, which was preying on the system, has been eradicated. The behaviour of the wound, however, is frequently disappointing. Many heal up and give no further trouble, often healing by first intention. An apparently firm scar is left in about two to three weeks; this now gradually stretches, becoming thin and blue, and at last gives way, leaving a rough, yellow, granulating surface exuding a little clear serum and tissue debris. The wound then heals slowly by granulation, often leaving a small but obstinate sinus to remind the surgeon of his half-success. The reason of all this is that unless precautions are taken, the tubercle bacillus is widely sewn over the raw surfaces. The bacillus takes a long time to grow, during which time the wound heals soundly, and later a slowly spreading tubercular cellulitis invades the newly formed scar tissue and breaks it down. For this reason tubercular tissue should be removed as far as possible in one piece, in the same way as tissue which contains the elements

of malignancy. Fully six months must elapse before the success of the operation can be proclaimed.

It is of great service if, instead of sending the patient back to the squalid surroundings from whence he came, he is sent for some weeks to a convalescent home in the country, preferably at the seaside. In patients who have rapidly advancing phthisis, only those operations should be performed which relieve conditions, which by their pain or misery are wearing away the strength of the patient ; for example, a fistula in ano. A slowly advancing tubercular condition in the lungs is not to stand in the way of operations on bones and joints, but would rather be taken as an indication for radical operation ; for, if freed from the pain and worry, and rid of one focus of disease, nature may be quite well able to overcome the remaining lesion in the lungs.

Diabetes.—No surgeon willingly performs an avoidable operation on a patient who is passing large quantities of sugar in his urine. Apart from the fact that the condition is often associated with peripheral neuritis, trophic lesions of the skin, and degeneration in the vessel walls, the tissue resistance to bacteria is lowered to a remarkable extent, so that the formation of boils and abscesses is of frequent occurrence. Little wonder then if wounds are prone to suppurate. An attempt should be made by dieting to arrest, or at all events to decrease, the amount of sugar that is being passed. If this can be done the safety of the operation is greatly increased.

Gangrene of a distal portion of a limb is not of infrequent occurrence in this disease, and in these cases the degeneration in the vessel walls is found extending high above the lesion, so that a high amputation is called for.

Visceral conditions

The Heart.—Valvular and degenerative changes of the heart have a deleterious effect on the whole circulation, tending chiefly towards stagnation of the blood in the peripheral parts. The circulation is not so brisk, œdema is liable to occur, and we may suppose that the process of inflammation normally occurring after any incision may be slightly modified and the scar take a longer time to become firm. If the valvular lesion is fully compensated, the result practically is nothing, provided that the want of exercise does not cause flatulence and embarrassment of the heart. The question of the anæsthetic would have to be carefully considered.

The Blood Vessels.—Atheroma is a great factor in deciding the site and shape of many wounds. The disease limits the blood

supply of the limbs to a marked extent, and in amputations drives the surgeon to high levels and to the region of joints where the collateral circulation is freer than elsewhere. The shape of the flaps is also a consideration; the risk of sloughing precludes the use of long flaps and favours the removal of the limb by the circular method or by equal flaps. Contrary to expectation, the rigid vessels tolerate the ligature well; secondary hæmorrhage sometimes occurs, but is rare.

The Lungs.—Any condition of the air passages or lungs which causes coughing and straining has a bad effect on wounds of the neck, throat, or abdomen. The circulation may be embarrassed as in emphysema, where the same effects may be seen as are brought about by valvular lesions of the heart. The surgical bearing of tuberculosis of the lungs has already been dealt with. In the aged acute affections of the lungs are always to be dreaded.

The Alimentary Tract.—Affections of the alimentary tract have little influence on the natural course of wounds, provided that the patient is not prevented from taking sufficient nourishment. Operations should not be performed during or just after a severe attack of diarrhœa. This rule must be rigidly adhered to in the case of small children.

The Liver.—Cirrhosis, fatty, and amyloid degeneration of the liver all have a profound effect on the general health of the individual, and when present in an advanced state render him ill-suited for operation. The chief causes of these conditions—alcohol, gluttony, a sedentary and unhealthy mode of life—have already been touched upon. The bearings of amyloid degeneration have yet to be dealt with; they depend very largely on the extent of the affection. The individual is usually the subject of long-standing suppuration on an extensive scale. The disease is first detected by the presence of a slight amount of albumin in the urine, the presence of casts, slight hepatic enlargement, with perhaps occasional diarrhœa. In the early stages such as this it is an indication that the time has arrived for a radical operation, and that if the life of the patient is to be saved half measures can no longer be dallied with. If the area of suppuration is removed, as by amputation, the waxy change in the viscera will disappear. Extensive amyloid degeneration evinced by hepatic enlargement, poly- and albuminuria, and chronic diarrhœa is an absolute bar to operative treatment.

Operations performed on those who are jaundiced are open to the increased risk of hæmorrhage, for the presence in the circulation of the bile salts diminishes the coagulability of the blood.

This can be overcome, to some extent, at all events, by administering large doses of calcium chloride for some days before and after operation.

The Kidneys.—No change in the general health nor disease of any other viscus has a more disastrous effect on the progress of an operation than certain diseases of the kidney. All operations, from catheterization onwards, must be considered hazardous when conducted on the subjects of albuminuria and pyuria, or on those suffering from acute or chronic nephritis. It follows therefore that no case should be operated on before the condition of the urine has been carefully ascertained. Imperfect elimination of waste products renders the tissues particularly suitable for the growth of organisms, so that suppuration is common. Even if one kidney is healthy, the result of the operation may be that it strikes work, and suppression of urine and death may ensue. It is hardly necessary here to emphasize the fact that in no case should one kidney be removed until the condition of the other has been satisfactorily ascertained. Patients with albumin or pus in the urine who have to undergo an operation should previously be kept in bed for some time, be given suitable diet, and undergo a course of urinary antiseptics.

The Preparation of the Patient

It is never a wise thing to let an individual work up to the last moment before operation. A few days quietly spent are very beneficial in accustoming him to the irksomeness of confinement and getting him used to his surroundings. It is a bad plan to operate on patients the day after they arrive in hospital, when, to them, everything is still strange. In emergency operations the urgency of the case overrides these and many other details, which, however, should never be omitted in an operation *de complaisance.*

The Diet and Bowels.—The diet for the few days previous to the operation should be nutritious but simple, and calculated to leave but little intestinal residue. If the operation is to take place at nine or ten in the morning, a little beef tea should be given at not later than six or seven respectively ; no food should be given by the mouth less than three hours before the anæsthetic, and then it should be of such a kind that it is easily absorbed.

The bowels should be well cleared out with castor oil or other purgative the day previous to the operation. An enema is usually given on the morning of the operation, and the nurse should see that it is all returned. For operations on the rectum

frequent and copious enemata may be given with benefit so as to evacuate this portion of the bowel. It is unwise to have antiseptics in the enemata, unless of the mildest description, as they can produce toxic symptoms if retained and absorbed. An enema containing a small amount of lysol has been known to produce alarming symptoms within half an hour, some portion being retained above a cancerous stricture.

Preparation of the Patient's Skin.—Until quite lately there were many routines in use for the preparation of the skin. All attempted to render the skin as sterile as possible. It is admitted by the advocates of all the different methods that while the skin can be freed from all organisms on its surface, the deeper layers and the ducts of the sebaceous and sweat glands cannot be sterilized, so that the surface can again be infected from the deeper layers. But while this is the case, it must be admitted that for the time being we are able to free the surface from all pathogenic organs, while even those that remain in the ducts probably have their virulence and powers of growth much diminished by the application of antiseptics.

The methods of sterilization of the skin have become much simplified during the last few years with the disappearance of the large wet antiseptic poultices which used to be applied. If time is not pressing, a hot bath should be taken by the patient the evening previously, and the part well scrubbed with soap and water, and, if necessary, shaved. He then puts on clean linen and goes to bed. Next day, on the table, one of two methods may be used: either the skin is washed with ether soap, which is removed with ether or methylated spirit, or the skin is painted with a 2 per cent. solution of tincture of iodine. Both these methods render the skin quite dry, so that nothing can trickle into the wound from the surface. Both methods are reliable; nevertheless, as soon as the incision has been made, the cloths or towels should be clipped to the edges so that all skin is excluded from the field of operations and no instrument can come in contact with it.

Preparation of the Surgeon's Hands.—The preparation of the hands of the surgeon and of his assistants is a most important matter, as they come in contact with, and are therefore liable to infect, the raw surfaces laid bare by the knife. The hands should be washed with soap and brush under a running stream of hot water, which carries off all extraneous matter as soon as it is freed. Fluid ether soap, turpentine soap, sapoform, or other antiseptic soap may be used. The washing should be done systematically, every portion of the fingers, hands, and forearms

being gone over methodically, special attention being paid to the nails, which should always be kept short. The hands and arms are then rinsed in some antiseptic solution and rubbed dry with a sterile towel or sterile swab; better than either of these is the method of dipping them in ordinary methylated spirit, which will evaporate very quickly, leaving them perfectly dry.

During the course of a long operation the hands perspire to some extent, and may become reinfected from the sweat glands; they should therefore be frequently dipped into an antiseptic solution. This, however, is not so necessary if indiarubber gloves be worn. If gloves are worn, arrangements should be made so that they can be put on dry, so that fluid does not continually leak from them into the depths of the wound. The question of gloves is, however, referred to again when the prevention of infection is dealt with.

The Preparation of the Instruments.—All instruments used in the operation should previously be boiled for five minutes in water to which a little soda has been added to prevent tarnishing.

If no gloves are worn the instruments should be laid in a weak antiseptic solution. If gloves are worn it is better to keep the instruments quite dry and simply lay them on a sterile towel, if wet they are extremely slippery and difficult to manage. Instruments should always be kept in a more or less sterile condition. This is attained by careful washing after each operation, to remove all organic matter in which organisms could possibly live; they should then be boiled, dried, and placed in a clean cupboard.

SEPSIS, ANTISEPSIS AND ASEPSIS

Nowhere within the range of medical science can the phrase "prevention is better than cure" be more truly applied than in the consideration of infection of wounds. Putrefaction and suppuration are now known to be the result of the action of micro-organisms which have in some way or other gained access to the tissues. Micro-organisms abound everywhere within the range of practical surgery, on the skin, clothing, articles of furniture, in water, and in the ordinary air. Though present in countless millions, comparatively few are pathogenic. But these under favourable circumstances are capable of multiplying to an unlimited extent, and if allowed to flourish in the tissues may cause the death of the patient. It is to prevent their growth

in the tissues that so many seemingly elaborate precautions are taken. Our chief endeavour is to exclude them as far as possible from the field of operation. To do this with anything like certainty we must understand the different ways by which these organisms may reach a wounded surface. Success in gaining first-intention healing depends entirely on our ability to understand and shut these ways of approach, and the greater the number we can close the higher will be our percentage of successes.

Organisms find their way to wounded tissues by two main routes: firstly, from within the individual himself—autoinfection; and secondly from outside—implantation. Of these two ways the latter is by far the commonest.

Infection from within, or Autoinfection.—Here the organisms have got into the system by routes other than the wound itself, such as lesions in the respiratory, alimentary, or genito-urinary systems. From the lesion wherever situated the organisms gain the circulation; here they probably do little harm until the resistance of the tissues is lowered locally, as by an incision with a knife. Here they settle, and if the vitality of the tissues and blood is not strong enough to overcome them, the baneful effect of their action is soon seen. The only way we can exclude the possibility of this risk is to submit the patient to a thorough medical examination before undertaking the operation. This has already been insisted upon under a previous heading. The better the general health of the individual the less likelihood is there of autoinfection occurring.

Infection from without, or Implantation.—Here the organisms are directly implanted in the open wound. This implantation may occur in many ways, which we will consider *seriatim*, together with the steps necessary for its prevention. It is obvious that implantation of organisms can only take place by bringing in contact with the wound substances which have not previously been sterilized, or, having been sterilized, have been allowed again to become septic.

1. *The Air.*—When at rest the air becomes practically sterile, all the organisms being carried down as the dust settles. When, however, the air is in motion, either by a draught or by people moving about, the dust and organisms are stirred up and settle anywhere, and in this way pathogenic organisms may settle in an open wound. The majority of the organisms present are non-pathogenic, and in operating theatres which are kept comparatively free of dust very little harm results. In private houses, where dust is abundant, there is naturally more risk, but it is

far better to let everything alone than to go round "dusting," which only ensures that all the dust which had already settled is again floating in the air. Of the number of people in the room the fewer there are the better, and they should move about as little as possible.

If, however, we can afford to neglect the ordinary air, it is far otherwise with the air of infected rooms. In the older hospitals there is no doubt that death from sepsis was frequently caused by infection which was borne by the atmosphere of ill-ventilated wards. Bad drainage has a great influence on the number of bacteria which can be cultivated from the air, so that sinks and closets in the neighbourhood of an operation, though very handy for the management of the slops, must always be regarded as a possible source of danger if cleanliness is neglected.

The air may also be infected from the mouths of those present. When talking particles of moisture are constantly being spluttered into the atmosphere, and this moisture contains organisms which are deposited a short distance from the mouth, and are therefore liable to be implanted in the wound. The risk is greatly increased when large numbers of pathological organisms are present, as when a person is suffering from tonsilitis, a cold, or has carious teeth. Washing the mouth and gargling with some antiseptic is a good safeguard against such infection in ordinary cases. The best preventive is a mask of sterile gauze, or a strip of three or four thicknesses of gauze laid across the mouth and nose and tied behind the head.

2. *The Instruments.*—These, if taken and put into wounds without being previously sterilized, will naturally implant organisms wherever they touch. The method of sterilizing instruments by boiling has already been mentioned. It is important to see that, after sterilizing, the instrument does not come into contact with any surface which is not also sterilized. Surrounding the field of operation with sterile cloths is a safeguard against this. As skin surfaces are never above suspicion, care should be taken that the instrument does not even come in contact with the patient's skin near the wound, if this can be avoided. For the same reason the handle which is grasped by the hand of the surgeon is liable to become infected; the practice therefore of cutting one moment with the blade and the next moment dissecting with the handle of a knife should not be encouraged.

3. *The Clothing.*—Clothing in the vicinity of a wound, whether belonging to the patient or to those taking part in the operation, will infect the tissues if allowed to stray too near. The patient's clothing and the patient's body must be completely protected

with sterile cloths. The surgeon and his assistants wear sterile aprons from their collars downwards to their wrists and below their knees. These should be made to fasten at the back, and may be worn over mackintosh aprons.

4. *The Patient's Skin.*—Unfortunately neither the skin of the patient nor the hands of the operator can be submitted to the best of all disinfectants, namely, moist heat, so that less reliable methods of disinfection have to be resorted to. The method of preparing the skin has already been detailed. It has also been pointed out that all methods are far from ideal. The necessity of leaving a very limited area of skin uncovered with sterile towels or cloths consequently becomes apparent. Hence also the need for preventing ligatures and instruments coming in contact even with this small area. In most cases sterile towels or cloths can be clipped to overlap the sides of the wound, so that all skin is excluded from the field of operation.

5. *The Hands.*—These form another weak link in the chain of prevention. The hands, like the skin elsewhere, can only be made relatively sterile. If attempts were made to obtain cultivations from the hands after they have been prepared in the manner previously laid down, it would probably be found that none would grow. But after waiting some little time, during which the sweat glands are allowed to act, it is found that a few cultivations can be grown. It is, however, probable that the organisms so grown have only a very attenuated virulence.

It is quite manifest that the difficulty of sterilizing the hands will be greatly increased if, to start with, they possess much septic material. Accordingly those whose hands come constantly into the proximity of sterile wounds should endeavour to follow the doctrine of "abstinence" advocated so strongly by Kocher, Barker, and others—abstinence, that is, from contamination of the hands with highly septic materials such as pus. Every means at disposal should be taken when dealing with septic wounds to prevent soiling of the hands. More especially is this needful shortly before the performance of a clean operation. Much may be done by management, dirty dressing being postponed till after operations, or performed by some one who takes no part in the operation. On the operating list the clean cases should come first. Infected wounds should be touched with sterile instruments instead of the bare hand. Lastly, rubber gloves should be worn when dealing with pus or other highly infected fluids. And this brings us to the consideration of the question of the wearing of gloves during operations.

Owing to the admitted failure of guaranteeing the sterility of

the hands for any length of time, Mickulicz introduced the wearing of white cotton gloves during operations. The hands were prepared with the same care as before and the gloves sterilized. It was hoped that any organisms which were present on the hands would be caught in these cotton gloves. But as the gloves rapidly became wet, either with blood or the fluid in which the instruments lay, their action as a filter was destroyed, so that unless they were constantly changed, an inconvenient proceeding during an operation, they were of little practical value. They never had a wide vogue, and have now quite disappeared. Indiarubber gloves, however, form a very good barrier to the passage of organisms so long as they are in good condition and do not leak. They have decided drawbacks. They blunt the sense of touch in a very marked degree; this, however, is not such a disadvantage as it appears, for instruments are being used more and more in place of the fingers in operations. The hand confined in a glove sweats more than it otherwise would, and the interior of the glove rapidly becomes septic. This may be a danger if the gloves are put on wet, as fluid escapes at the wrist and runs down into the wound. It is easy to nip or prick the gloves unperceived, and the fluid thereby escapes into the wound, which is thus infected by a far more concentrated solution of organisms than if no gloves were worn. The difficulty in handling instruments is largely overcome by practice; they are only slippery if wet, and so should be used dry. The gloves themselves should be put on dry; this can easily be done, for if the hands are dried in spirit and then powdered with a dusting powder which has been sterilized by heat, no difficulty will be experienced in drawing on the dry gloves.

Fashion has decreed that, for the present at all events, all those in constant surgical practice shall wear gloves if they can be procured, although practical experience in a large number of cases has shown that if the ungloved hands are kept reasonably clean, are thoroughly washed before operation, and frequently rinsed in fluid during the course of the operation, the risk of infection is very small.

But there is another preventive measure which is not yet fully recognized, but which has for some time been insisted upon. That is that the hand, whether gloved or bare, should not come in contact with the tissues more than is absolutely necessary. It must be granted that no instrument can give to the surgeon the same amount of information as an educated finger, but the habitual use of the fingers can be restricted greatly. If at any time the tissues have to be palpated, all the information

required can usually be obtained through a double layer of sterile gauze. This acts as a filter in the same way as the cotton glove, a new piece of gauze being used each time. Few can realize without having seen the method how many and extensive operations can be accomplished with perfect ease, the fingers at no time being brought in contact with the cut surfaces. Sterile instruments can be used exclusively to hold the tissues, to retract the edges of the wound, and to manipulate the swabs. Though the technique may seem a little strange at first, very little practice will enable one to perform many operations without experiencing even the desire to touch the raw surfaces with the naked hand. By cultivating the practice of "abstinence," thorough cleansing, and the substitution of boiled instruments for the fingers the risk of implanting organisms by the hand can be reduced almost to nothing.

6. *The Ligatures and Buried Sutures.*—When foreign material has to be left in the wound in the form of ligatures and buried sutures, the nature of the material used becomes a serious consideration in aseptic healing.

We may take it for granted that the less foreign matter that is left in a wound the less the risk of infection occurring through it. If the artery forceps are well made and firmly applied, they will, in the majority of instances, have caused complete occlusion of any small vessel by the time they are removed. The twisting of vessels also helps to do away with the use of the ligature. But, in spite of these measures, ligatures have frequently to be applied, and buried sutures are often needed.

Catgut has the advantage that after a variable amount of time, depending on the method of preparation, it is absorbed, being itself an animal tissue. On the other hand, it needs most careful preparation to render it aseptic; in its dry state it is extremely foul; it will not stand boiling; it ties in rather a bulky knot, and there is always the chance that it may be absorbed too soon.

Silk or linen thread has the advantage that it can readily be sterilized by boiling; it ties in a very small knot, and in tying pedicles it is not so liable to slip as catgut. But against this is the fact that it is never absorbed and always remains as a foreign body in the tissues. Long after the wound is soundly healed it may, though rarely, cause suppuration, and a sinus forms which will not heal until the stitch itself is discharged or removed.

If the catgut is well prepared and the silk or linen thread well boiled, there is probably very little to choose between them.

For strong buried sutures kangaroo tendon is well spoken

of by those who use it; after a while it becomes incorporated in the tissues as a part of themselves.

7. *The Sutures.*—The best material for suturing the skin is silkworm gut. It is smooth, strong, and possesses no capillary action, and therefore there is no danger of conveying organisms from the skin to deeper parts of the wound. The material irritates the skin very little, so that the sutures can be left in for ten or fourteen days without fear. Silk or linen thread has to be removed in about eight days; both get soaked with the tissue fluids, but silk has much more capillary action than linen thread.

8. *The Dressings.*—The dressings applied to the wound must previously be sterilized with steam. They must reach well beyond the wound in all directions and form a protective covering till the wound has healed. If the margins of the wound are in good apposition the edges stick together in a very few hours, and the risk of infection is then small. In many wounds where there is little exudation a collodion dressing may be applied and left on till healing is completed, the dressings outside this serving merely as a support to diffuse the pressure and prevent any fluid collecting in the depths of the wound. Sealed dressings are of great use in parts of the body where ordinary dressings are likely to get soiled, as in operations for hernia.

Having now dealt with the methods of infection and shown that in some particulars, even in favourable circumstances, our protective measures fail and that a wound is liable to become infected with a few organisms, either from the air, hands, or from faulty sterilization or technique, we must now shortly consider how it is that the great majority of wounds heal quite well and the percentage of failures, in wounds originally clean, is so small as to be somewhere in the decimals.

It is probable that if the tissues are healthy organisms may be deposited in the wound without danger, if they are few in number and do not possess great virulence, because the tissues are able both to limit their growth and to destroy them. This power of resistance lies in the lymph of the tissues and the serum of the blood, and is called the opsonic power. What happens is that the opsonic power of the serum stimulates the phagocytic action of the white blood corpuscles. This power varies in different individuals, and at different times in the same individual, some having a low, some a high, opsonic index to the various organisms. But even a high opsonic index will fail to protect if the amount of sepsis is too large; it becomes then

very much a question of the size of the dose and the virulence of the dose.

It does not come within the scope of this work to deal with the manner in which the opsonic index can be raised, but this can and should be done where time permits and where infection from certain organisms is greatly feared.

It is obvious also that the life of the tissues operated upon must be interfered with as little as possible. Division with the knife or scissors causes the minimum of injury; no unnecessary tearing or bruising must be indulged in. Besides the avoidance of mechanical injury, chemical and thermal injury must also be guarded against. The tissues exposed must not become too dry, but should be douched with sterilized saline at the temperature of the body or a little higher. No irritating antiseptic solutions should be applied to the raw surface, for they would probably not act long enough to kill any organisms present while they might devitalize the tissues to such an extent as actually to favour the growth of organisms.

The difference between an antiseptic and an aseptic technique is that in the former you continue to use antiseptic lotions all through the course of the operation, applying them even to the raw surfaces, the field of operation is surrounded by towels rung out of carbolic, and the instruments are kept in carbolic solution; while in the latter rigid antiseptic precautions are taken up to the time the operation commences and are then laid aside, and nothing of a septic or irritating nature is brought in contact with the wound.

In the first case possible infection is guarded against all through at expense of damaging the tissues to some extent; in the second it is believed that an aseptic field has been produced, and, if that is so, normal saline solution is the only fluid that should come near the wound; the hands are washed in it, the instruments dipped in it, and the wound flushed out with it. The aseptic method is the ideal one, but can only be attained in very suitable circumstances, such as operations performed in the modern operating theatre and the best nursing homes. In operations in private houses some routine is usually followed about half-way between the two methods.

GENERAL PRINCIPLES

The Knife and Methods of Holding it.—Different sized knives are used to supply the needs of different operations. The scalpel is the knife generally used to make ordinary incisions and to carry

out delicate dissections. It should be made, blade and handle, in one continuous piece of metal. The blade may vary from three-quarters to two and a half inches in length; it should be middle-pointed, that is to say, the edge and back should both slope to the point which lies in the long axis of the handle. The back should be blunt to the very tip. The handle should be four inches long and about half an inch broad.

In carrying out fine dissections the scalpel is generally held in the "pen" or dissector's position, as shown in Fig. 1. Here

FIG. 1.—PEN POSITION.

FIG. 2.—VIOLIN BOW POSITION.

the movements can be made with great accuracy, as the hand is steadied by resting on the little and ring fingers.

In making freer incisions where the hand has to travel some little distance, and where firmness may possibly be needed, the scalpel is best grasped by all the fingers opposing the thumb in the violin-bow position (Fig. 2). With a little practice the most delicate dissections may also be carried out with the knife held in this manner.

Where more force is required and a large scalpel used, as in excisions of joints, the knife is best held in the ordinary dinner-knife position (Fig. 3).

FIG. 3.—DINNER-KNIFE INCISION.

Making the Incision.—The skin to be incised is steadied by the left hand, the incision commencing between the forefinger and thumb. The edge of the knife must be held at right angles to the skin surface, and not slanting to either side. The whole thickness of the skin should be divided at the first stroke. The incision should be of equal depth throughout, and should not shallow off at the ends. To ensure this the knife must start with firmness so as to divide the skin at once, and towards the end of the incision the handle of the knife must gradually be raised so that at the finish it is held nearly vertical to the skin. The succeeding strokes should also

deepen the incision equally throughout its entire length, so that the edges of the wound appear clean cut, and not ragged or chopped.

Blunt Dissection.—Tearing and bruising is to be discountenanced; it is bred of fear and incompetence to use the knife. Blunt dissection may be of great use in opening up muscular and cellular planes to find vessels, or to separate the bladder from the uterus, but its use must be distinctly limited.

Anatomical landmarks should be noted and disturbed as little as possible; important structures such as nerves and tendons which do not need division are drawn to one side with retractors.

In dealing with deep wounds, retractors are necessary and most useful. Blunt hooks are the simplest and most convenient form of retractors for small wounds. For larger wounds and more forcible retraction larger hook-like instruments must be used. In choosing them a handle of which a good grip can readily be taken is most important, as the fingers of an assistant rapidly tire and slip if this is lacking. Tissue forceps with a catch or narrow pieces of metal, which can be bent to any desired shape, are both useful forms of retractors.

The Arrest of Hæmorrhage.—The wound must be kept free from blood, or the deeper parts rapidly become obscured. Dry swabs of gauze grasped in ordinary dissecting forceps are momentarily pressed over the bleeding point by the assistant; on removal the vessel is seen leaking, and can be caught with artery forceps. The vessels must be grasped cleanly and as little tissue as possible taken up with each. The forceps are firmly clamped and the handles dropped to one side of the wound.

A sufficient number of forceps are applied to arrest all the hæmorrhage and allow a clear view. When cutting down in the neighbourhood of any large vessel which has to be divided, caution must be used as its position is approached; if it is seen it is clamped with two pair of forceps and divided between them, a proceeding entailing no loss of blood. In dealing with still larger vessels, they can be dissected out and divided between two forceps, as just described, a proceeding not always suitable, or the main blood supply may be controlled either by a tourniquet or by digital pressure, the vessels are cut across and secured as soon as convenient. For many of the smaller vessels the forceps are quite sufficient, and when taken off the vessel is found occluded. For those of slightly larger size torsion may be applied. The vessel is pulled well out and twisted until no more resistance is encountered. Larger vessels and those not occluded in these ways will need a ligature. The assistant holds up the handle

of the forceps, and the surgeon passes a ligature of about eight to ten inches in length round the forceps. The assistant at once depresses the handles of the forceps, so that the blades gripping the vessel point up towards the surgeon. The surgeon ties the first part of the knot and makes sure that the ligature grasps the vessel, a thing it does naturally if the forceps are held correctly. A reef-knot is used to secure the vessel, tied in the way shown in Fig. 9. The beginner does well to practice the tying of knots until dexterity is acquired.

Closing the Wound.—When the object of the operation has been attained, the edges of the wound are retracted and the

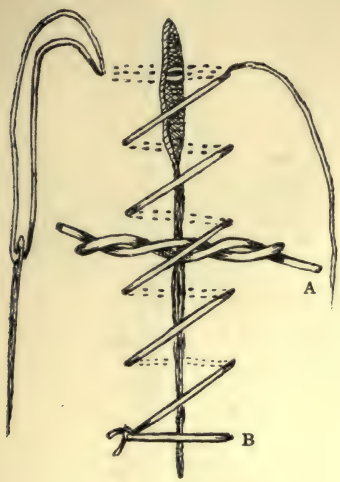


FIG. 4.—SUTURES.
A, Interrupted suture. B, Simple continuous suture.

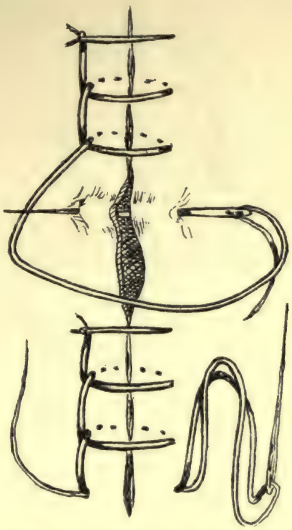


FIG. 5.—BLANKET STITCH.

depths flushed out with warm saline solution to remove all blood clot and loose tissue.

The Skin is Sewn up in one of the following ways :—

1. *The Interrupted Suture.*—Here a series of separate sutures is used to close the wound. These sutures should pierce the skin from a quarter to half an inch from the margin of the wound, and are tied with sufficient tightness to hold the edges of the skin in accurate apposition ; if tied too tightly the edges are apt to roll in and delay healing. In using silkworm gut the simplest knot to tie is the first stage of the surgical knot, in which one end is doubled under the other twice (Fig. 4, A). This lies quite

flat on the skin, does not come undone, and can be tightened up or loosened at will. With other materials a reef-knot must be used.

In closing large wounds, especially those which are curved, it is not a good plan to begin at one end of the wound and work to the other, for often it is found that after a few stitches the edges do not correspond. To make them correspond accurately the first stitch should be placed so as to approximate the middle of each margin ; the next two are placed one on each side, so as to divide the wound into quarters. The succeeding stitches sub-

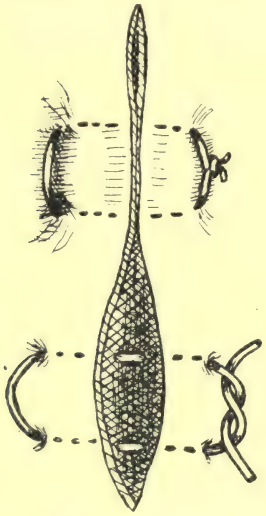


FIG. 6.—TENSION SUTURES.

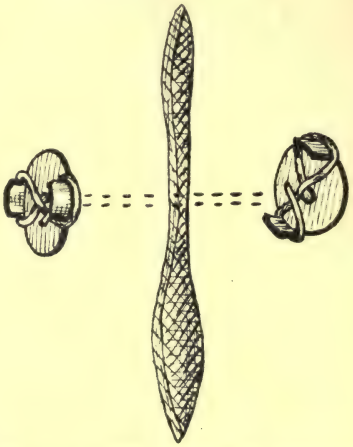


FIG. 7.—WIRE TENSION SUTURES, WITH LISTER'S METAL BUTTONS.

divide the spaces between the preceding ones until a sufficient number are in place.

2. *The Simple Continuous Suture.*—This is a simple over-and-over stitch (Fig. 4, B). It is begun at one end of the wound, where the free end is knotted, and carried through the skin at regular intervals till the other end is reached and here finished off. If this is used, the tension must be adjusted accurately by pulling up each loop in turn towards the end before tying off, as when once tied the tension cannot be altered. Different methods of finishing off the suture are shown in the accompanying figures.

3. *The Blanket Suture.*—This is shown in Fig. 5 ; it holds the edges of the wound together with great accuracy and takes

very little longer to insert. The continuous sutures are most useful, as they close a wound quicker than the interrupted, which involves tying a knot and cutting short the ends of each one after insertion. The continuous suture also requires the threading of fewer needles.

4. *The Tension Sutures.*—In large wounds where there is much tension, or where the flaps on each side are heavy and tend to drag apart, " tension sutures " are needed to take a firm hold on the tissues and hold them steady while the " apposition sutures " appose the edges with greater accuracy. The tension

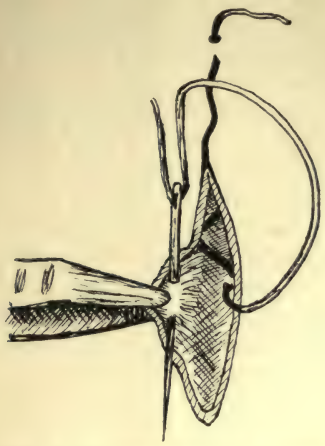


FIG. 8.—SUBCUTANEOUS SUTURE.

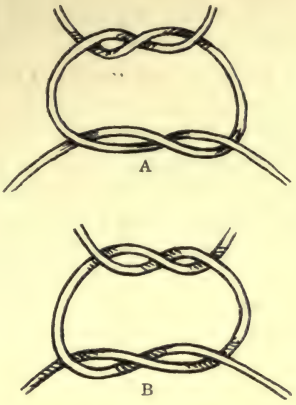


FIG. 9.—KNOTS.
A, Reef knot. B, Granny knot.

suture is inserted first, and when the strain is relieved the apposition sutures are introduced.

The simplest form of tension suture is just an interrupted suture which takes a large grasp, passing deeply into the subcutaneous tissue entering and emerging about three-quarters of an inch from the wound.

Probably the best form of tension suture and the one most used is known as the mattress suture. It is inserted at one side of the wound and emerges at a corresponding point on the other side ; it is then sent back in the opposite direction about half to three-quarters of an inch from its original track. This stitch not only relieves tension, but serves to evert the skin margins and prevents them becoming rolled in.

If the tension is extreme, as is sometimes the case after excision of the breast, Lister's metal plates or buttons and silver

wire may have to be used. Strong silver wire threaded on a special wire needle is passed across the wound from and to points about one and a half inches to one side of the cut edges. One end of the wire is now threaded through and twisted up over a flat metal plate ; the other end is strongly pulled upon and twisted up, after threading through a second metal plate, which is pressed down hard upon the skin. A very considerable amount of tension may in this way be exercised on the adjacent skin without the stitches cutting out. Large plates diffuse the pressure better than small ones.

5. *The Subcutaneous Suture.*—This is used to do away with the ugly marks sometimes left by the stitches. It is useful in positions like the face and neck, where the presence of scars is a disfigurement. The needle is introduced beyond one end of the incision and brought out of the wound ; the free end of the suture, which is usually fine silkworm gut, is grasped with artery forceps. The needle is made to pierce the deeper layers of the skin and the subcutaneous tissue on alternate sides of the wound till the other end is reached. The needle is then thrust out through the skin beyond this end of the incision. On pulling on the two ends of the suture the edges of the wound should come accurately in apposition. All tension must be relieved before applying this suture, and a good deal of practice is needed to make it a success.

CHAPTER II

Ligature of Arteries

Preliminary remarks—Arteries of the lower limb—Arteries of the upper limb—Arteries of the head and neck.

PRELIMINARY REMARKS ON THE LIGATURE OF VESSELS

A large number of the operations for the ligature of vessels, which are included in every text-book of operative surgery, are of no practical value to the operating surgeon. They are, however, extensively used upon the cadaver as exercises by which the student and young surgeon acquires a facility in the proper use of instruments, and in the application of his anatomical knowledge to surgical procedures.

In examinations, two or more operations are set the candidate, in order that he may display the skill and knowledge above referred to. One of these operations is almost sure to be the exposure and ligature of some vessel. Particular attention therefore should be directed to the technique by which he is expected to carry out this procedure.

The chief points to which attention is directed are—

1. The incision.
2. The landmarks.
3. The opening and separation of the vessel sheath.
4. The application of the ligature.

1. **The Incision** must be placed correctly if the operation is to proceed smoothly—all the marks for the operation may be lost through failure to start aright. The line of the vessel should be estimated with care, and may be marked upon the skin with the finger nail. To do this precisely, the part may have to be manipulated into a certain position, as, for instance, in taking the line of the femoral artery, the thigh must be slightly flexed, abducted, and rotated outwards. Again, in dealing with the common carotoid artery, if the head be rotated too far to the opposite side, the anterior border of the sterno mastoid may be

missed, the muscle split, and the internal jugular vein opened into before one is aware of its proximity. An incision made only half an inch from the line of a superficial artery, such as the dorsalis pedis, may make the operation almost impossible in a foot on which the skin has become slightly dry. Everything therefore may depend on the exactness with which the first incision is placed. The proverb, "what is well begun is half done," is never more true than in its application to these operations.

The incision to start with should be made of sufficient length, prolonging the incision later when difficulties arise makes the edges of the wound irregular, and is a sign of incompetence—in all probability the difficulties would have been avoided if the incision had been of proper size. Only the very superficial arteries can be exposed through an incision of less than two inches in length, two and a half to three and a half inches is an average length. The method of making incisions has already been laid down, together with the correct way of holding the knife.

2. **The Landmarks.**—Almost every vessel has in its neighbourhood other anatomical structures which are more easily recognized than the vessel itself. When these structures or landmarks are exposed and recognized, the anatomical knowledge of the operator enables him to tell exactly where the vessel lies. It is therefore of the utmost importance that the landmarks of each operation should be recalled to mind, together with any possible variation which is liable to occur. The student is reminded that most of the landmarks should be exposed *to view*, and not merely felt for—if he will remember this, fewer mistakes will be made as the result of forcibly thrusting in a finger in the vain effort to feel the vessel. The finger in the majority of cases only displaces the landmarks and makes them less valuable. If the operator will display his landmarks in order, the vessel will display itself.

3. **The Opening and Separation of the Vessel Sheath.**—When the sheath of the vessel has been exposed, a small transverse fold should be picked up by holding the forceps at right angles to the vessel. If a longitudinal fold is grasped there is a danger of opening into one of the accompanying veins. The transverse fold is divided by the knife immediately beyond the grasp of the forceps, the knife being held as much on the flat as possible. The sheath should be divided for about one-third of an inch, never for more than half an inch, as the vessel wall is nourished by small vessels (vasa vasorum), which run in the sheath and enter the vessel. In order to preserve the nourishment of the vessel wall at the point of ligature, it is important not to strip

off these vessels over too great an area. After opening the sheath sufficiently the knife is laid aside and should not be needed again.

One side of the slit sheath is held by the dissecting forceps, while the artery on that side is freed by means of an aneurism needle. The needle is moved gently from side to side as it is insinuated under the artery; it is difficult to pass the needle more than about three-quarters of the way round the artery, and no attempt should be made to do so at this stage. When the vessel is freed thus far, the needle should be kept in place behind the vessel, while the grip of the forceps is transferred to the opposite side of the slit in the sheath. The needle is now withdrawn and reintroduced on the side of the forceps. The remainder of the circumference of the vessel is then freed until the needle can be passed completely round. It is sometimes difficult to free the back of the vessel, and the grip of the forceps may have to be shifted alternately from one side to the other. It is important to remember that the needle should always work away from the forceps. If an important structure, such as a nerve or a vein, is lying in close proximity to the vessel, the sheath on that side should be grasped by the forceps and the final passage of the needle should be away from both the instrument and the structure to be avoided. Some people prefer to use a director to free the artery from its sheath. There is no advantage in so doing, as a straight instrument does not get behind the vessel as well as a curved one; moreover, some examiners display a rooted dislike to the use of the instrument, regarding its use as a sign of incompetence.

4. **The Application of the Ligature.**—The needle must always be passed unthreaded; it is threaded when in position and then withdrawn, leaving the ligature in place. The ligature is tied in a reef knot, the first portion of which is drawn sufficiently tightly to sever the inner and middle coats of the vessel, the second portion of the knot is then tied, and, as an extra precaution against slipping, a third knot is often added. Sometimes the ligature is tied in what is known as a surgical knot, which is made by giving an extra twist to the first half of the ordinary reef knot. The first half of the knot should be carefully tied at right angles to the course of the vessel, a forefinger being applied to the ligature on each side close up to the knot; the coats of the vessel are more easily divided in this manner, and the vessel is not dragged out of its bed. A considerable amount of practice is needed before the ligature can be applied with precision and rapidity. There are many different ways of actually tying the

ligature, but the beginner should practice only one until dexterity is acquired.

When the operation is finished, the wound should be sewn up neatly with closely applied interrupted sutures. These give good practice in the tying of knots. Interrupted sutures should always be used for the limbs of the cadaver, for when later the amputation flaps are being marked out the sutures do not run like a continuous suture does if it happens to be cut. On the trunk continuous sutures may be practised without disadvantage.

In examinations accuracy is of greater importance than rapidity.

ARTERIES OF THE LOWER LIMB

THE DORSALIS PEDIS ARTERY

Anatomy.—This artery commences in front of the ankle joint, as a direct continuation of the anterior tibial and ends in the sole of the foot by completing the plantar arch. The course of the vessel is marked by a line drawn from the front of the ankle, midway between the two malleoli, to the proximal end of the first interosseous space. The artery lies on the bones all the way, between the tendon of the extensor proprius hallucis and that of the extensor longus digitorum to the second toe. It is crossed in its lower part by the innermost tendon of the extensor brevis digitorum. The inner division of the anterior tibial nerve lies to its outer side.

Operation.—An incision one and a half inches long is made exactly in the line of the vessel from the lower margin of the anterior annular ligament. The incision lies midway between the tendons of the long extensors to the first and second toes. The incision is gradually deepened. The small tendon of the flexor brevis will come into view at the lower part of the wound. The artery is found close to the bone. The needle is passed from the outer side to avoid the nerve.

THE ANTERIOR TIBIAL ARTERY

Anatomy.—The artery arises at the back of the leg at the lower border of the popliteus muscle, by the bifurcation of the popliteal; it ends in front of the ankle joint by becoming directly continuous with the dorsalis pedis. The course of the artery is marked by a line drawn midway between the head of the fibula

and the outer tuberosity of the tibia, to the centre of the front of the ankle joint. In its upper part the vessel is deeply situated, but it becomes more superficial as the muscular bellies give place to tendons. On the front of the leg it rests in the upper two-thirds of its course on the interosseous membrane, below that on the tibia. In the upper third of the leg the artery lies between the tibialis anticus on the inner side, and the extensor longus digitorum on the outer side. In the middle third of the leg the extensor proprius hallucis muscle, as well as the longus digitorum, lie to the outer side. In the lower half of the leg the proprius hallucis gradually crosses in front of the artery, and its tendon comes to lie on its inner side at the ankle joint. The anterior tibial nerve approaches the outer side of the artery in the upper third, lies directly in front in the middle third, and immediately to the outer side again in the lower third.

Position.—The limb is held in the same position as for ligature of the dorsalis pedis (see Fig. 10). In applying the ligature

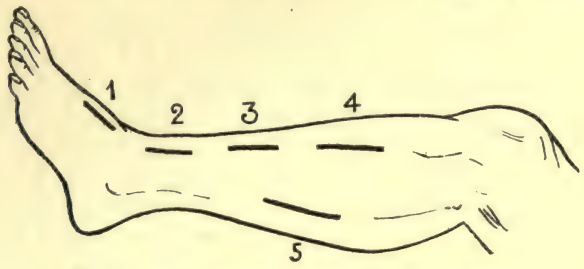


FIG. 10.—SURFACE MARKING OF THE LEG.

1 Dorsalis pedis. 2 Anterior tibial above the ankle. 3 Anterior tibial lower third of the leg. 4 Anterior tibial at junction of upper and middle thirds. 5 Peroneal artery.

in the upper third the assistant should rotate the leg inwards, so that the line of the vessel is uppermost.

Ligature in the Lower Third

Operation.—The tendon of the tibialis anticus must be identified, and an incision two inches long is made in the line of the artery immediately to the outer side of this tendon. The deep fascia, which is here specially thickened to form the upper and transverse portion of the anterior annular ligament, is divided. The interval between the tendons of the tibialis anticus and the extensor proprius hallucis is defined; the latter tendon lies in front as it is crossing the vessel, its tendon is drawn outwards, and the artery exposed lying on the bone. The

nerve lies immediately to its outer side. The vessel is cleared of the veins, and the needle is passed from the nerve.

Comment.—The synovial sheath of the tibialius anticus is the only one which reaches to this level; the operator should avoid opening it.

Ligature in the Middle Third of the Leg

Operation.—An incision three inches long is made over the course of the vessel, the deep fascia exposed in the whole length of the incision, the yellowish interval between the tibialis anticus and the communis digitorum is identified, and the deep fascia opened over it. The muscles are retracted, the ankle being slightly flexed to relax them; this will bring into view the extensor proprius hallucis lying under cover of the communis digitorum. Both muscles are retracted outwards. The nerve is now exposed lying in front of the artery. The nerve is drawn to one side and the needle passed away from that structure.

Ligature in the Upper Third of the Leg

Operation.—The limb is rotated inwards. The line of the artery should be carefully determined and marked on the skin with the finger-nail. An incision three and a half inches long is made precisely over the course of the vessel. The deep fascia which is exposed for the whole length of the wound is so arranged that the fibres run downwards and inwards towards the tibia, the fascia is very dense and gives origin to the underlying muscular fibres. No intermuscular line can be seen. The fascia is divided throughout in the line of the incision; the muscular fibres are cleared from the under surface of the fascia for a third of an inch on each side. This should be done from below upwards, the knife being held on the flat so as not to rag the muscles. The forefinger of the left hand is now used to define the intermuscular space between the tibialis anticus and the extensor communis digitorum. When once this is found the muscles are retracted and the depths of the wound opened up.

The artery lies on the interosseous membrane close to the outer border of the tibia. If small veins are seen coming to the surface between the muscles, they form an excellent guide to the vessel. The nerve, if seen, is to the outer side of the artery. The needle is passed from without inwards, and the venæ comites must be included in the ligature.

Comment.—The chief difficulty lies in finding the intermuscular space, as it cannot be seen, but can be felt if the finger is pressed

on the two muscles after the facia is divided. On no account should attempts be made to find it with the blade of the knife. The intermuscular space between the extensor communis and the peroneus longus, further out, must not be mistaken for it.

THE POSTERIOR TIBIAL ARTERY

Anatomy.—The posterior tibial artery arises at the lower border of the popliteus muscle by the bifurcation of the popliteal, and ends at the lower border of the internal annular ligament midway between the internal malleolus and the prominence of the heel, by dividing into the external and internal plantar arteries. The course of the artery is marked out by a line drawn from the centre of the popliteal space to the point just mentioned.

FIG. 11.—INCISIONS FOR POSTERIOR TIBIAL.

The artery lies from above downwards on the tibialis posticus, flexor longus digitorum, the tibia, and the ankle joint. In the upper two-thirds it lies under cover of the gastrocnemius and soleus, while in the lower third it is subcutaneous, and can be felt beating during life. The vessel is accompanied by two venæ comites. The posterior tibial nerve lies on the inner side for a short distance, and then crosses the vessel posteriorly and lies on its outer side. Behind the ankle joint the structures from within outwards are: the tibialis posticus tendon, the flexor longus digitorum tendon, the vessels, the nerve, and, lastly, the flexor longus hallucis tendon. The tendons all lie in separate synovial compartments attached to the bone. The non-synovial compartment containing the vessels and nerve is broad and shallow.

Position.—When applying a ligature to any part of the posterior tibial artery, the patient lies on the back with the

hip and knee flexed, and the leg laid on the outer side; a sand-bag may be placed under the knee. The surgeon stands on the outer side and bends over the limb.

Ligature behind the Ankle

Operation.—A curved incision two inches long is made half an inch behind and parallel to the posterior border of the internal malleolus. The knife is directed towards the tibia. The wound is deepened and the internal annular ligament divided. The finger feels for the interval between the tendon sheaths. In it

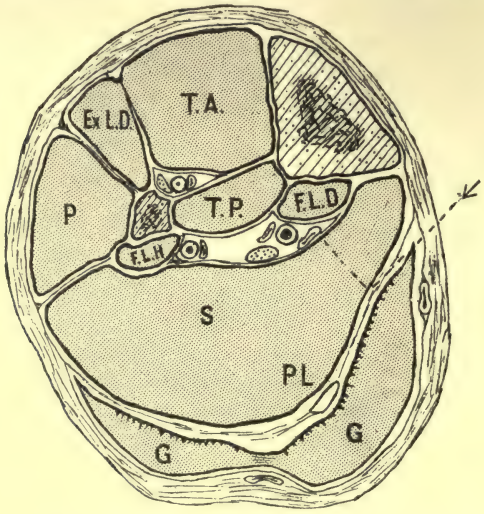


FIG. 12.—DIAGRAMMATIC SECTION THROUGH THE CALF.
Dotted line indicates change of direction needed to find the posterior tibial artery.

the artery and nerve can be felt, the artery is the more superficial. The synovial sheaths must not be opened. If the vessel divides higher up than usual, two arteries may be seen; they should be secured separately.

Ligature in the Lower Half of the Leg

Operation.—An incision two inches long is made in the line of the artery midway between the inner margin of the tendo Achillis and the inner border of the tibia. The deep fascia is divided, and the upper part of the internal annular ligament may be encroached upon. The artery is exposed, lying on the

flexor longus digitorum with the nerve on its outer side. The needle is passed from the nerve.

Comment.—There is a tendency in both these operations to wander too far outwards and to burrow under the tendo Achillis; this can be avoided if the wound is always deepened towards the tibia.

Ligature in the Middle of the Leg

Operation.—An incision, three and a half to four inches long, is made parallel to and three quarters of an inch behind the inner border of the tibia. The incision is deepened and the saphenous vein, if seen, is drawn aside. The deep fascia is divided throughout the incision. As a rule the thin inner margin on the gastrocnemius muscle is now seen and drawn outwards, exposing the aponeurotic surface of the soleus muscle. The next step is most important. The knife is held horizontally with the edge directed at right angles to the soleus and the muscle divided for the whole length of the incision, parallel to, but quite half an inch behind, the inner border of the tibia. In dividing the muscle the knife cuts towards the bone; the muscle is a quarter to half an inch thick. The posterior edge of the wound is retracted and the fingers introduced to feel for the artery as it lies on the fascia over the flexor longus digitorum close to the outer border of the tibia. The vessel is felt, the fascia divided, and the needle passed from behind forwards to avoid the nerve on the far side.

Comment.—Great difficulty may be encountered in finding this vessel if the soleus is not divided in the way recommended. If the muscle is divided too close to the inner border of the tibia, the intermuscular space between it and the flexor longus digitorum will be missed and the later muscle ploughed up in efforts to find it. The mistake usually made is to enter the substance of the flexor longus digitorum and to displace the artery outwards and backwards.

THE PERONEAL ARTERY

Anatomy.—The peroneal artery is given off the posterior-tibial about one and a half inches below the origin of that vessel; it ends in the lower third of the leg by dividing into anterior and posterior branches. The vessel at first passes outwards between the tibialis posticus and the soleus to reach the fibula. It then descends along the inner margin of that bone, lying in a fibrous

canal between the attachments of the flexor longus hallucis and the tibialis posticus.

Ligature in the Middle of the Leg

Position.—The patient lies on the sound side in the semi-prone position, with the knee flexed and the leg resting on its antero-internal surface.

Operation.—The outer border of the fibula is carefully defined. An incision of three and a half inches long is made parallel with and immediately behind this border of the bone (see Fig. 10). The incision is deepened and the outer border of the soleus muscle exposed. The muscle, which is here free from the bone, is retracted outwards and the bone exposed. The fibres of the flexor longus hallucis are divided close to the fibula till the fibrous canal is exposed. The muscle is retracted, the canal is opened, and the artery found lying against the inner border of the fibula. The needle may be passed in either direction.

THE POPLITEAL ARTERY

Anatomy.—The popliteal artery arises at the opening of the adductor magnus, as the direct continuation of the femoral, and ends at the lower border of the popliteus muscle by dividing into the anterior and posterior tibials. The point where the artery ends is on a level with the lower part of the tubercle of the tibia. The artery passes obliquely downwards outwards to the middle of the popliteal space, and then runs vertically to its termination.

It lies from above downwards behind the popliteal surface of the femur from which it is separated by fatty tissue, on the posterior ligament of the knee joint, and, lastly, on the popliteus muscle. The upper part is overlapped by the semimembranosus, the lower part by the two heads of the gastrocnemius. The popliteal vein lies to the inner side of the artery below, then crosses behind it to lie on the outer side above. The two vessels are bound together by fascia. The internal popliteal nerve passes vertically down the space on a more superficial plane lying to the outer side of both vessels above, and to their inner sides below. In the lower part of the space the sural branches of the artery, the tributaries of the vein, including the short saphenous vein, and the muscular branches of the internal popliteal nerve, all lie superficial to the artery, and render

any attempt to approach the vessel from this direction very difficult.

Ligature of the upper part of the artery

(*Joubert's Operation*)

Position.—The patient lies on the back with the hip flexed and the knee bent to a right angle ; the thigh is rotated outwards to expose its inner aspect. The surgeon stands on the outer side of the limb.

Operation.—The tendinous portion of the adductor magnus is defined and traced to the adductor tubercle on the internal condyle of the femur. An incision three inches long is made parallel to and immediately behind this tendon. The internal cutaneous nerve, if seen, is drawn aside. The anterior edge of the sartorius is exposed and displaced backwards with the deep branch of the anastomotic artery, which must not be wounded. The internal saphenous vein is not usually seen.

The wound is deepened and the tendon of the adductor magnus brought into view and drawn forward. The semi-membranosis is defined and retracted backwards. The finger is gently inserted across the popliteal surface of the femur, close to the bone, and then rotated so that the back of the finger is towards the bone. The pulp of the finger should then lie against the vessel. The artery is cleared and the needle passed from below upwards towards the bone.

Comment.—The operation is not difficult if the several muscles are recognized in turn. The artery is not so far from the surface as the student is apt to imagine; the vein may not come into view.

THE FEMORAL ARTERY

Anatomy.—The femoral artery commences behind Poupart's ligament as the direct continuation of the external iliac, and ends at the opening in the adductor magnus by becoming directly continuous with the popliteal artery. To mark out the course of the vessel, the hip must be slightly flexed, abducted, and rotated outwards. A line is then drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle on the internal condyle of the femur. The upper two-thirds of this line marks the course of the artery. The upper third in Scarpa's triangle, the middle third in Hunter's canal. The artery lies from above downwards on the psoas, pectineus, and adductors longus and magnus.

Only occasionally does the adductor brevis come in contact with the artery below the pectineus.

In Scarpa's triangle the artery is superficial, being crossed at the apex by the internal cutaneous nerve. In Hunter's canal, the vessel lies under cover of the sartorius. The vein lies behind and to the outer side of the artery in the canal, directly behind at the apex of Scarpa's triangle, on the same plane and to the inner side in the femoral sheath. The internal saphenous vein lies three-quarters of an inch to the inner side of the artery in the groin. The internal saphenous nerve lies in front and to the outer side of the artery in the canal.

The origin of the profunda femoris varies widely, but, as a rule, is situated one and a half inches below Poupart's ligament; the origins of the two circumflex vessels are half an inch below

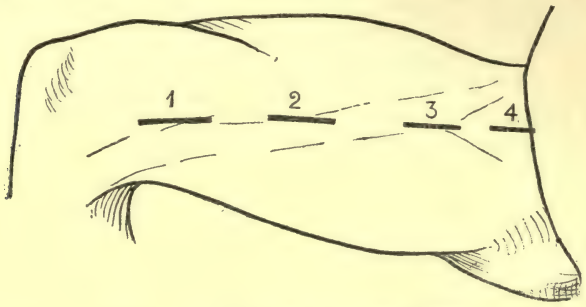


FIG. 13.—INCISIONS IN THE THIGH.

1, The popliteal artery. 2, The femoral in Hunter's canal. 3, The femoral at the apex of Scarpa's triangle. 4, The common femoral.

that. At the apex of the triangle the order of structures from before backward is the femoral artery, femoral vein, adductor longus, profunda vein, and profunda artery.

Position.—In applying a ligature to any part of this artery the limb is placed in the position already detailed for marking out the course of the vessel.

1. Ligature in Hunter's Canal

Operation.—An incision three inches long is made opposite the middle of the thigh, precisely in the line of the artery. The internal cutaneous nerve and the long saphenous vein may be seen, and are displaced to one side inwards. The deep fascia is divided throughout the wound, and the sartorius muscle recognized. Its fibres run downwards and inwards, while those of the vastus internus pass downwards and outwards. The outer

edge is cleared and the sartorius is drawn inwards. The strong fascial roof of the canal is exposed; its fibres pass transversely from the adductors to the vastus internus. The artery may be felt with the finger through the roof of the canal. This fascia is divided and the artery exposed with the internal saphenous nerve lying in front and to its outer side. The vein is behind, and may not be seen. The needle is passed from the nerve, and must be kept close to the vessel to avoid wounding the vein.

Comment.—Nearly all the difficulties which are met in this operation are due to misplaced incisions. The internal saphenous vein may be opened, the inner instead of the outer border of the sartorius exposed, or the vastus internus muscle may be cut into.

2. At the apex of Scarpa's Triangle

Operation.—In a thin subject the apex of the triangle can be seen; in a fat subject this is not the case, and the apex must be judged to be about three and a half inches below Poupart's ligament. An incision three inches long is made directly over the line of the artery; the centre of the incision should be opposite the apex of the triangle. The fascia lata is incised for the whole length of the wound. The fibres of the sartorius are recognized passing downwards and inwards. The inner margin of the muscle is sought and retracted outwards. The finger now feels for the vessel. As the artery is exposed, the internal cutaneous nerve will be seen crossing it obliquely, and possibly the long saphenous nerve will come into view on its outer side.

The vein lies behind the artery. The sheath is opened and the needle passed from the nerves.

3. Ligature below Poupart's Ligament

Operation.—The ligature is applied above the origin of the profunda femoris; this part of the artery is often referred to under its old name of the common femoral. In a thin subject the vessel may be made out by the finger. An incision two inches long is made over the course of the vessel immediately below Poupart's ligament. The superficial epigastric and circumflex iliac arteries may be seen, and should be drawn aside. The iliac portion of the fascia lata is divided immediately to the outer side of the saphenous opening. The artery can now be felt by the finger. The anterior layer of the femoral sheath is divided and the vessel cleared. The needle is passed from

within outwards. The vein should not be seen; it lies shut off in the next compartment of the femoral sheath.

NOTE.—In class work this operation should be postponed in one or more subjects, as it is more instructive to ligature the vessel as the first step in disarticulating at the hip by the anterior racket method. As a rule the artery has been opened on one side for the injection of preservatives.

Collateral Circulation.—

Internal and superficial external pudics	with the deep external pudic.
Deep and superficial circumflex iliacs	with the external circumflex.
Obturator,	with the internal circumflex.
Gluteal and sciatic	with the two circumflex and the perforating arteries.

After ligature above the profunda, the vessels at the back of the thigh take on a large amount of the functions of the main artery. The comes nervi ischiadici, which morphologically is the remnant of the old main artery, may become directly continuous with the popliteal vessel.

THE EXTERNAL ILIAC ARTERY

Anatomy.—The external iliac artery is three and a half to four inches in length, and commences opposite the lumbo-sacral articulation by the bifurcation of the common iliac artery; it ends behind Poupart's ligament by becoming directly continuous with the femoral artery.

The course of the vessel may be marked by a line drawn from a point three-quarters of an inch below and to the left of the umbilicus to a point midway between the anterior superior iliac spine and the symphysis pubis. The upper third of this line corresponds to the common iliac, the lower two-thirds to the external iliac. The artery lies at first along the inner side of the psoas and then in front of that muscle; it is enclosed in a sheath of the iliac fascia. In front of the vessel, on the left side, are the peritoneum with the attachment of the pelvic meso-colon and the commencement of the pelvic colon; while on the right is the termination of the ilium, and often the appendix. The ureter crosses the termination of the common iliac, and is attached to the peritoneum. The lower part of the vessel is crossed by the vas deferens and the spermatic vessels in the male, and the round ligament of the uterus in the female. In both sexes this part of the vessel is crossed by the genital branch of the genito-crural

nerve and the deep circumflex iliac vein. Almost invariably there is a lymphatic gland situated in front of the termination of the artery. The external iliac vein lies to the inner side of the vessel below, but as it passes upwards it comes to lie rather behind the artery.

The deep epigastric artery arises about a quarter of an inch above Poupart's ligament, while the deep circumflex iliac arises behind that structure. The internal abdominal ring lies just in front of the artery and to the outer side of the deep epigastric artery.

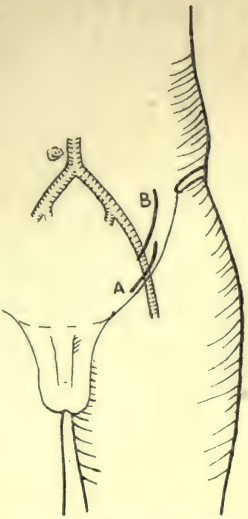


FIG. 14.—INCISIONS FOR EXTERNAL ILIAC ARTERY.

A, Sir Astley Cooper's incision for ligature of the external iliac. B, Abernethey's incision for ligature of the external iliac.

A. Ligature by the Extra-peritoneal Route

This method is the one usually adopted in examinations, but as the modern trans-peritoneal route is now sometimes asked, the student should make himself familiar with both.

Position.—The patient lies on the back with the thighs together. The surgeon stands upon the side to be operated upon. Broad retractors and suitable aneurism needles with lateral curves should be provided.

1. *Sir Astley Cooper's Method*

Operation.—An incision three and a half inches long is made, starting a quarter of an inch above and a little to the inner side of the mid-point of Poupart's ligament. The inner two-thirds of the incision lies parallel to the ligament; the outer third curves slightly away from that structure to end about an inch internal to the anterior superior iliac spine.

The integuments and the superficial epigastric artery are divided. The apponeurosis of the external oblique is exposed and divided in the direction of its fibres. The edges of the wound are drawn aside, and the conjoined tendon will be seen or felt towards the inner end of the wound, while the muscular fibres of the internal oblique are noted in the outer half. The muscular fibres of the internal oblique are divided to the outer end of the incision, and the fascia transversalis fully exposed.

This fascia is divided very cautiously to avoid injury to the deep epigastric artery which lies immediately behind it, and is a good guide to the main vessel.

The space in the extra-peritoneal tissue now exposed is enlarged by pushing the peritoneum gently inwards with the fingers till sufficient of the artery comes into view. The peritoneum is held back by a broad retractor while the vessel is being cleared. The needle is passed away from the vein. The ligature should be applied a little over an inch from the termination of the artery.

2. *Abernethy's method*

Operation.—An incision three and a half to four inches long is made from a point half an inch above the middle of Poupart's ligament. It extends upwards and outwards to end one and a half inches above and internal to the anterior superior spine of the ilium. The integuments are divided and the superficial circumflex iliac vessels secured. The apponeurosis of the external oblique is divided in the direction of its fibres. The inner arched margin of the internal oblique is defined and the finger slipped under its edge; no instrument should be used. The muscle is divided on the finger for the whole length of the wound. The same procedure is repeated in dealing with the transversalis muscle in the outer part of the wound. The fascia transversalis is now fully exposed and cautiously divided throughout the incision; it varies greatly in density, and when poorly developed in a subject with little extra-peritoneal fat the peritoneum is very liable to be opened. The exposed peritoneum is pushed in gently with the fingers; no instrument of any sort should be used to do this. The iliacus muscle covered with the fascia iliacus is exposed; to the inner side of this the rounded psoas is seen. The inner margin of the wound is retracted inwards with a broad retractor which protects the peritoneum, while the artery is sought and identified on the inner edge of the psoas. Its fascial sheath must be opened and the vessel cleared. The needle is passed from within outwards—from the vein.

Comment.—Sir Astley Cooper's method is the easier of the two. Its advantages are that the artery is superficial, little muscular tissue is divided; the peritoneum is displaced less, is here only slightly adherent, is easy to push aside, and, therefore, runs less risk of injury. The vein also is in a better position to escape damage. Against the operation are urged the proximity of the wound to the abdominal rings, the presence of the deep epigastric artery, and, in real life, the proximity of the ligature

to collateral branches, or to an aneurism in the groin if that is the reason for its application.

Abernethy's method demands a wide division of muscles, a deep wound, and a more extensive displacement of the peritoneum from a situation where it is more adherent. The vein, too, is here very awkwardly placed during the passage of the needle. The risks of a hernia developing subsequently are about equal in the two methods. In real life the choice lies between Cooper's method and a trans-peritoneal operation.

For obvious reasons Abernethy's method is still frequently set in examinations, but should the choice be left to the candidate, Cooper's operation should always be performed.

B. Ligature by the Trans-peritoneal Route

Position.—When performing this operation in the living, the Trendelenburgh position will be found most helpful. In the cadaver the position is the same as in the last operation.

Operation.—An incision three inches long is made in the linea semilunaris, reaching to within an inch of Poupart's ligament. The peritoneal cavity is opened in the usual way. The deep epigastric artery, if seen, must be carefully preserved. The coils of small intestine are pushed to one side and packed off with gauze. The position of the artery is ascertained on the inner edge of the psoas muscle. The parietal peritoneum covering the vessel is picked up and divided for about an inch. The vessel is then cleared of fascia and the needle passed from within outwards. The peritoneum is sutured over the ligature, and the abdominal wound closed in the usual way.

Collateral Circulation.—*In front.*—The superior epigastric and lower intercostals with the deep epigastric.

Outer side.—Ilio-lumbar and gluteal with the circumflex iliacs and the ascending branch of the external circumflex.

Behind.—Gluteal and sciatic with the two circumflex and the first perforating at the crucial anastomosis.

Inner side.—Obturator with the deep epigastric and internal circumflex. Internal pudic with the external pudics.

THE COMMON ILIAC ARTERY

Anatomy.—This artery is about two inches long, the right being slightly longer than the left. The vessel arises at the bifurcation of the abdominal aorta opposite the middle of the

body of the fourth dorsal vertebra to the left of the middle line, and ends in front of the lumbo-sacral articulation by dividing into internal and external iliacs. For the line of the vessel, *see* p. 36.

Each vessel has behind it the bodies of the fourth and fifth lumbar vertebræ with the intervening disc, the psoas muscle, and the sympathetic cord. The artery on the right side is separated in the upper two thirds of its course by the commencement of the inferior vena cava, the right common iliac vein and the termination of the left common iliac vein. In front of both vessels are the peritoneum, coils of small intestine, and numerous sympathetic twigs passing from the aortic to the hypogastric plexus. On the left side there are, in addition, the inferior mesenteric vessels. The ureter crosses the bifurcation of the artery. The vein on the left side lies internal to its artery, that on the right lies behind, crossing gradually from within outwards.

The operation is seldom performed even in examinations, while the old extra-peritoneal methods have quite disappeared.

1. Ligature by the Trans-peritoneum Route

Operation.—An incision four inches long is made in the middle line below the umbilicus. The peritoneum is opened in the usual way, and the coils of intestine drawn to one side. The position of the vessel is made out with the finger. The peritoneum on the posterior abdominal wall is picked up and divided vertically over the artery. The sympathetic nerves and areolar tissue are cleared; while on the left side the inferior mesenteric vessels have to be pushed aside. The needle is passed from the vein, that is from within outwards on the left side and from without inwards on the right.

Comment.—The operation is easy, especially in thin subjects, and is easier on the right than on the left side as the inferior mesenteric vessels do not complicate matters.

2. Ligature by the Extra-peritoneal Route

Operation.—An incision five or six inches long is made from one and a half inches above the centre of Poupart's ligament, upwards and outwards to pass one and a half inches internal to the anterior superior iliac spine. The muscles are each divided in turn in the way described in the ligature of the external iliac artery. Between the internal oblique and the transversalis, the ilio-inguinal, ilio-hypogastric, and last dorsal nerves are met.

These if possible should be drawn aside. The transversalis fascia is divided and the peritoneum displaced inwards with the usual caution. If the body is rolled over to the opposite side retraction of the peritoneum is easier in the depths of the wound. The ureter is displaced forward with the peritoneum. The needle is passed from right to left on both sides.

THE INTERNAL ILIAC ARTERY

Anatomy.—This artery is about one and a half inches in length, and arises in front of the ilio-lumbar joint by the bifurcation of the common iliac, it ends at the upper border of the great sciatic notch by dividing into anterior and posterior divisions. Posterior to the vessel are the internal iliac vein and the commencement of the common iliac vein, behind these lie the lumbo-sacral cord. Separating the vessel from the lateral wall of the pelvis are the external iliac vein and the obturator nerve. Internally, the artery is covered by peritoneum, and is crossed by the tributaries of the vein. The ureter runs downwards immediately in front and slightly internal to the artery.

1. Ligature by the Trans-peritoneal Route

Operation.—The steps of this operation are very similar to those detailed in dealing with the common iliac artery. The peritoneal cavity is opened in the middle line below the umbilicus. Large retractors must be used to keep the intestines out of the way. The finger follows the common iliac artery down until the internal iliac artery is defined. The peritoneum over the artery must be opened freely and the fatty tissue displaced. The vein is the chief difficulty, but the position of the ureter must be remembered. The needle is passed from behind forwards—from the vein.

2. Ligature by the Extra-peritoneal Route

Operation.—This is performed in exactly the same way as that for ligature of the common iliac artery, with the difference that the incision may have to be prolonged upwards a little to give more room. The peritoneum is very liable to be injured, and great difficulty is encountered in passing the needle ; several instruments of different shapes should be at hand.

Comment.—With the advantages of asepsis, it is doubtful whether the extra-peritoneal method of ligaturing the artery

can be justified in real life. The candidate is practically never required to perform the operation.

THE GLUTEAL ARTERY

Anatomy.—This artery is the largest branch of the posterior division of the internal iliac. It emerges from the pelvis by

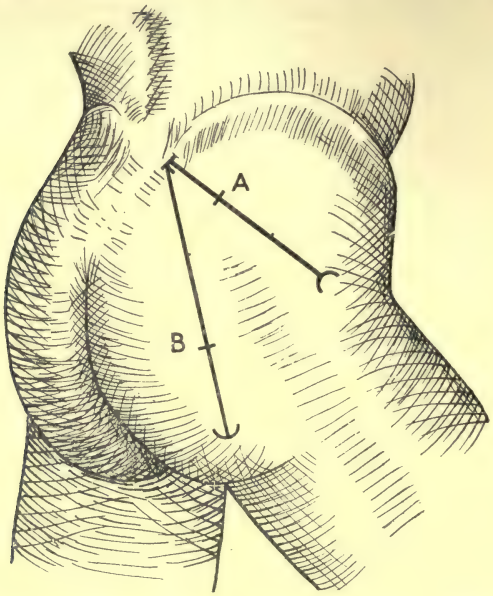


FIG. 15.—LINES FROM POSTERIOR SUPERIOR ILIAC SPINE TO GREAT TROCHANTER AND ISCHIAL TUBEROSITY.
A, Gluteal artery. B, Sciatic and pudic arteries.

winding round the upper border of the great sciatic notch, above the pyriformis muscle. The point of emergence can be marked on the surface by the junction of the upper with the middle third of a line drawn from the posterior superior iliac spine to the tip of the great trochanter. The artery only has a course of about half an inch in the buttock, and then divides into its superficial and deep divisions, the latter of which again divides into superior and inferior branches. The superior gluteal nerve lies in front of the vessel, while the large gluteal vein lies behind and superficial to it.

Position.—The subject is rolled over into the semi-prone

position, with the hip and knee flexed. The operator stands on the outer side of the limb.

Operation.—An incision five inches in length is made along a line joining the posterior superior iliac spine to the tip of the great trochanter. The centre of the incision should correspond to the point where the artery emerges from the pelvis. The incision is deepened through the fibres of the gluteus maximus, and the muscle retracted on each side. The gluteus medius and the pyriformis are now exposed, and a branch of the superficial division of the artery may be seen and will serve as a guide to the vessels. The interval above the pyriformis is opened up and the bony margin of the sciatic notch felt. The superior branch of the vessel is seen and followed back until the main artery is brought into view. The vein must be separated and the needle passed avoiding the vein and the superior gluteal nerve. The isolation of the artery is not easy as it lies at the bottom of a deep wound.

LIGATURE OF THE SCIATIC AND PUDIC ARTERIES

Anatomy.—Both these arteries are branches of the anterior division of the internal iliac. They leave the pelvis through the lower part of the great sacro-sciatic foramen, to appear in the buttock between the pyriformis and the quadratus femoris muscles. Their point of emergence is marked on the surface by the junction of the middle with the lower thirds of a line drawn from the posterior superior iliac spine to the ischial tuberosity. At this spot the sciatic artery is a little external and the more superficial of the two. The great sciatic nerve lies to their outer side. The pudic artery passes inwards and enters the small sacro-sciatic notch, lying exactly over the apex of the ischial spine between the nerve to the obturator internus and the pudic nerve, the latter lying to the inner side of the vessel.

Operation.—An incision four inches long is made downwards and outwards in the direction of the fibres of the gluteus maximus muscle, the centre of the incision being over the point of emergence of the vessels. The gluteus maximus is divided throughout the wound and the fibres retracted. The interval between the pyriformis and the quadratus femoris is sought. The sciatic artery should easily be recognized to the inner side of the great sciatic nerve. The pudic artery lies upon the ischial spine which should be defined before the vessel is exposed. The accompanying nerves must be avoided in passing the needle.

ARTERIES OF UPPER LIMB

THE RADIAL ARTERY

Anatomy.—The radial artery begins opposite the neck of the radius by the bifurcation of the brachial, and terminates in the palm of the hand by completing the deep palmar arch. The first part of the artery extends from its origin to the styloid process of the radius. The line of the vessel extends almost in a straight line between these two points. The artery rests from above downwards on the tendon of the biceps, the supinator brevis, pronator radii teres, flexor sublimis digitorum, flexor longus pollicis, pronator quadratus, and on the radius itself. In the upper half of its course it is overlapped by the supinator longus

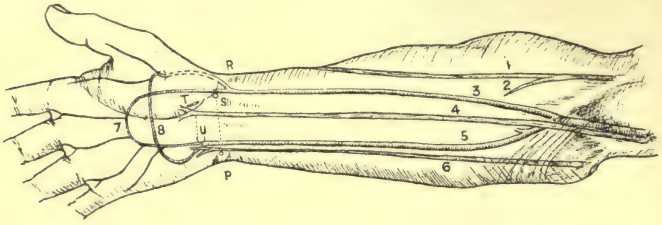


FIG. 16.—SURFACE MARKING OF THE FOREARM.

1, The radial nerve. 2, The posterior interosseous nerve. 3, The radial artery. 4, The median nerve. 5, The ulnar artery. 6, The ulnar nerve. 7, The superficial palmar arch. 8, The deep palmar arch. P, Pisiform. R, Styloid process of radius. S, Tubercule of scaphoid. T, Ridge on trapezium. U, Hook of unciform. The dotted lines, T, U, S, and P, represent the anterior annular ligament.

muscle, but in the lower part it is subcutaneous. The vessel is accompanied by two venæ comities. The radial nerve approaches the outer side of the artery in the upper third, lies in close proximity with the middle third and leaves it again in the lower third to wind round the outer side of the radius under cover of the supinator longus tendon. The second part of the artery extends from the apex of the styloid process of the radius to the proximal end of the first interosseous space, both of which points can easily be felt. The vessel lies on the external lateral ligament of the wrist, the scapoid, trapezium, and base of the first metacarpal bone. It is crossed by the tendons of the extensor ossis metacarpi pollicis and extensor brevis pollicis. The tendon of the extensor longus pollicis only just crosses the termination of the vessel.

Position.—The assistant holds the hand with the radial border uppermost and the thumb extended.

At the back of the Wrist (in the Snuff-box)

An incision about one inch in length is made from the styloid process of the radius down the centre of the space between the extensor tendons. This incision crosses the line of the artery almost at right angles. The cephalic vein of the thumb and a branch of the radial nerve may be seen and drawn aside. The incision is gradually deepened and the vessel exposed.

Comment.—If the operator is rash he may divide the artery before he is aware of its presence; opening the tendon sheath must be rigidly avoided.

Ligature of the First Part of the Artery

Position.—The limb is abducted and supinated and steadied by an assistant. The surgeon stands upon the outer side of the limb.

Ligature in the Lower Third of the Forearm

An incision is made two inches long in the line of the vessel; this is just external to the tendon of the flexor carpi radialis. The lowest part of the incision does not reach below the level of the wrist joint. The fascia is divided and the outer border of the tendon of the flexor carpi radialis made out, but its sheath should not be opened. The artery is felt immediately to the outer side of this tendon. An endeavour should be made to separate the veins from the artery.

In the Middle Third of the Forearm

An incision is made two and a half inches long in the line of the artery half way down the forearm. As the incision is deepened the superficial radial vein is seen and avoided. The margin of the supinator longus muscle is sought, the fascia is divided and the muscle drawn outwards. The artery is now exposed, lying on the insertion of the pronator radii teres, with the nerve to the outer side. The needle is passed away from the nerve.

Comment.—A common error is to mistake the outer for the inner border of the supinator longus muscle.

In the Upper Third of the Forearm

An incision two and a half inches long is made in the line of the vessel, and gradually deepened till the deep fascia is divided; the superficial vein, if seen, is drawn aside. The interval between the inner border of the supinator longus and the pronator radii teres is now defined. The fibres of the former muscle run vertically; those of the latter run obliquely. In muscular limbs the student will find that the inner margin of the supinator longus extends further in than he would at first suppose. On defining the inner margin, the muscle is drawn outwards, and the artery can easily be felt and exposed. The nerve is not in relation to the vessel, and the needle may be passed from either side.

ULNAR ARTERY

Anatomy.—The ulnar artery begins at the level of the neck of the radius by the bifurcation of the brachial and ends at the hook of the unciform by dividing into superficial and deep branches.

Line of the Vessel.—A line drawn from the front of the internal condyle of the humerous to the outer margin of the pisiform bone corresponds in its lower two-thirds to the course of the vessel. The upper part of the vessel curves inwards from here to the middle of the antecubital space. The vessel lies at first on the branchialis anticus, and then on the flexor profundus digitorum; at the wrist it lies on the front of the anterior annular ligament. In the upper part of its course it lies very deeply, being crossed by the pronator radii teres, flexor carpi radialis, palmaris longus, and the flexor sublimis digitorum. Lower down it is overlapped by the flexor carpi ulnaris muscle to within an inch of the wrist. The vessel is accompanied by two venæ comites. The ulnar nerve takes an almost straight course down the forearm, the two structures therefore approach each other in the upper third, and lie in close contact the rest of the way, the nerve being to the inner side.

Position.—The arm is fully supinated.

1. In the Lower Third of the Forearm

An incision is made two inches long in the line of the vessel, its lower border reaching just to the highest crease in

the front of the wrist joint. If a superficial vein is seen it is drawn aside, the tendon of the flexor carpi ulnaris is felt, and the deep fascia divided to its outer side. The wrist is flexed and the tendon drawn inwards. The vessel and the nerve are exposed. An attempt should be made to separate the venæ comites. The needle is passed from the nerve.

2. In the Middle of the Forearm

An incision about two and a half to three inches long is made in the line of the vessel. The anterior ulnar vein and twigs of the internal cutaneous nerve are usually exposed and are drawn aside. The deep fascia is divided throughout the length of the incision. The left fore-finger is introduced, and the interval between the flexor carpi ulnaris and the flexor sublimis digitorum felt for and opened up, the muscles being relaxed by flexing the wrist. When the interval is found the muscles are separated with retractors, and the ulnar nerve is seen. The artery lies immediately to its outer side. The needle is passed from the nerve.

Comment.—The incision must be precisely in the line of the artery. There is often a difficulty in finding the inter-muscular space, as the thin outer margin of the flexor carpi ulnaris overlaps the inner part of the flexor sublimis digitorum. If vessels are seen coming to the surface they form an excellent guide to the artery.

THE BRACHIAL ARTERY

Anatomy.—The brachial artery begins at the lower border of the teres major and ends opposite the neck of the radius.

Line of the Artery.—With the arm extended and abducted to a right angle, a line drawn from the junction of the anterior and middle thirds of the axilla to the middle of the bend of the elbow, marks out the course of the vessel.

The artery lies from above downwards on the long head of the triceps from which it is separated by the musculo spiral nerve and the superior profunda artery, on the long head of the triceps, insertion of the coraco-brachialis, and below that on the brachialis anticus. The artery is overlapped by the inner margin of the biceps, but it is otherwise superficial until it dips down into the ante-cubital fossa under cover of the bicipital fascia. The artery is accompanied by two venæ comites, the median basilic vein is separated from the lower end of the artery by the bicipital fascia

and the deep fascia as far as the middle of the upper arm, where the vein pierces the fascia and lies in close relation to the vessel. In many cases the venæ comites join this vein as soon as it pierces the fascia. The median nerve crosses in front of the artery from without inwards; in a small percentage the nerve crosses posterior to the vessel. The ulnar nerve lies to the inner side of the upper part of the vessel, and then gradually passes backwards through the internal intermuscular septum with the inferior profunda vessels.

Position.—The limb should be extended and supinated and supported by an assistant. If it is allowed to rest on a block this should not be allowed to reach above the olecranon. The surgeon may stand either on the outer or the inner side of the limb; the former position is preferable.

1. At the Bend of the Elbow

Operation.—The tendon of the biceps is carefully defined and an incision two inches long made along its inner border, from the level of the internal condyle downwards. The median basilic vein is always exposed, usually lying parallel to the incision; the vein is drawn to one side; it must not be wounded. The bicipital fascia is recognized by the downward and inward direction of its fibres; the fascia is divided in line with the original incision. The artery with its veins lies immediately under the fascia. The median nerve if seen lies to the inner side of the artery. The needle is passed from the nerve.

Comment.—The artery is quite movable, and may easily be displaced if the finger is carelessly used to find the vessel.

2. In the Middle of the Upper Arm

The inner margin of the biceps is defined, and a two and a half inch incision made along its inner edge. The basilic vein, if seen, is drawn aside. The deep fascia is divided and the inner edge of the biceps defined. The muscle is retracted slightly outwards, and the median nerve exposed and drawn inwards. The artery lies behind the nerve (*see* Fig. 17, A).

Comment.—This operation is the pons asinorum of operative surgery, and the application of a ligature to this superficial vessel is beset with many pitfalls, and yet, if attention is given to the following instructions, no difficulty should be experienced. The upper arm should be unsupported, as any support alters the relationships by pushing forward the triceps, so that the ulnar

nerve is exposed and mistaken for the median. In retracting the biceps the artery may be retracted also. The ligature may be applied in error to the basilic vein, the median, or the ulnar nerves, or the inferior profunda artery.

The following **abnormalities** of the artery are well recognized :—

1. The artery may run down towards the internal condyle and then pass inwards below an epicondylic process.

2. There may be a high division of the artery, in which case the median nerve passes between the two divisions, the anterior of which usually becomes continuous with the radial or interosseus artery, and is really a vas aberrans.

3. The median nerve may cross behind the artery, in which case the vas aberrans has completely replaced the normal vessel.

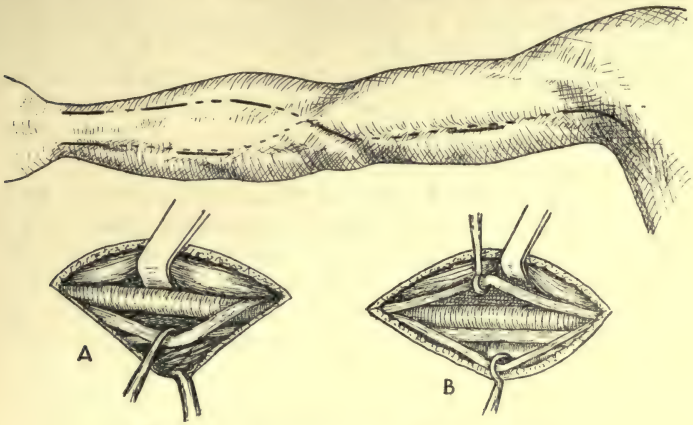


FIG. 17.—INCISIONS FOR UPPER LIMB.

A, Brachial artery. B, Axillary artery.

4. The artery may lie under a layer of muscle which is continued down the arm from the axilla, where a layer of muscle is sometimes found joining the pectoralis major to the latissimus dorsi.

THE AXILLARY ARTERY

Anatomy.—This artery begins at the outer border of the first rib as the direct continuation of the subclavian and ends at the lower border of the teres major by becoming continuous with the brachial.

Line of Artery.—With the arm abducted to a right angle, a line drawn from the centre of the clavicle to the inner border of

the coraco-brachialis will represent the artery. The artery is divided into three parts, according to the relation it bears to the pectoralis minor. The limits of the pectoralis minor may be marked out by lines drawn to the coracoid process from the third and the fifth costo-chondral junctions. The relations of the first and third parts only need considering.

First Part.—In front lie the pectoralis major, costo-coracoid membrane and the axillary sheath, while the clavicle and subclavius muscle overlie the upper part. The artery is crossed by the cephalic vein, while spread out in front of this are the branches of the acromio-thoracic vessels and the external anterior thoracic nerve, and a loop joining the external and internal thoracic nerves. Behind, the vessel is in relation to the first intercostal space, the second rib with the two digitations of the serratus magnus, and the nerve of Bell. The three cords of the brachial plexus all lie to the outer side. On the inner side of the vessel lies the axillary vein, but when the arm is abducted to a right angle the vein is drawn rather in front, and may conceal the artery. The vein is affected by respiration, and air is liable to enter if the vessel is wounded.

Third Part.—The third part of the artery is covered by the pectoralis major in its upper half, the remainder lying under the integuments and fascia with the internal cutaneous and the inner head of the median in front of it. It rests in order on the subscapularis and tendons of the latissimus dorsi and teres major muscles, with the circumflex and muscular spiral nerves behind it. To the outer side lie the coraco-brachialis muscle, the median and external or musculo cutaneous nerves. On the inner side, the ulnar nerve lies nearest the vessel, then the vein, and then the lesser internal cutaneous nerve (nerve of Wrisberg). Often the venæ comites and the basilic vein do not join till well up in the axilla. It will be noted that the artery has two nerves on every side.

Ligature of the Third Part

Position.—As in last operation.

Operation.—An incision three inches in length is made in the line of the vessel at the junction of the anterior with the middle thirds of the outer wall of the axilla. The deep fascia is divided and the inner margin of the coraco-brachialis defined. This muscle is retracted outwards, and the artery is easily felt in the middle of the bundle of nerves. The internal cutaneous nerve is drawn gently inwards, the median nerve drawn

outwards, and the artery exposed. The sheath is opened and the needle passed from within outwards, away from the vein.

Comment.—An abnormal layer of muscular fibres, which sometimes passes from the pectoralis major to the latissimus dorsi and covers in the outer wall of the axilla, must not be mistaken for the coraco brachialis.

Ligature of the First Part

Position.—The upper part of the body may be slightly raised by placing a sand-bag between the scapulæ and allowing the shoulders to fall well back. The arm should lie at the patient's side, but the shoulder must not be pulled down. The operator may stand near the shoulder or near the head, whichever he prefers.

Operation.—A curved incision three inches long with the convexity downwards is made so that its mid point is opposite and about one inch below the middle of the clavicle. The incision is deepened evenly until the clavicular portion of the pectoralis major is exposed. At the outer angle the cephalic vein must be avoided. The pectoral is divided throughout the length of the incision. The upper margin of the pectoralis minor is then defined; above this is the costo-coracoid membrane. This membrane should be divided vertically, well to the outer side, and not torn, as there is great danger of injuring the cephalic vein by such procedure. The upper border of the pectoralis minor is retracted downwards and the cephalic vein followed inwards to the axillary vein. Behind the cephalic vein, the axillary sheath, which is here very thick, is opened and the artery exposed. The needle is passed from the vein, which is carefully protected from injury.

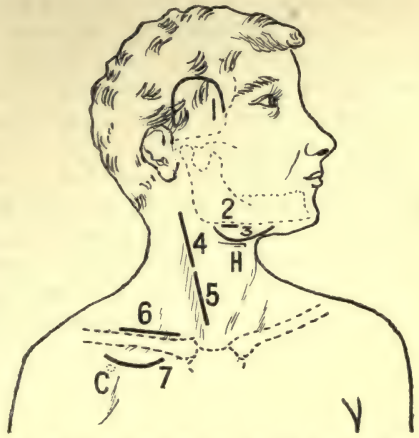


FIG. 18.—INCISIONS ON HEAD AND NECK.

1, Middle meningeal artery. 2, The facial artery. 3, The lingual artery. 4, The external carotid. 5, The common carotid. 6, The third part of the subclavian. 7, The first part of the axillary. H, Hyoid bone. C, Coracoid.

Comment.—If the operator tears in the depths of the wound

the veins are very liable to injury. Recognition of the landmarks is most necessary, for in the cadaver the finger can help little, as the artery is ill supported posteriorly, and the finger merely pushes the vessel before it deeper into the wound. The internal anterior thoracic nerve coming forward between the artery and the vein may prove an additional guide to the vessel.

ARTERIES OF HEAD AND NECK

THE SUBCLAVIAN ARTERY

Anatomy.—To mark out the artery on the surface draw a line convex upwards from the sterno-clavicular articulation to the mid-point of the clavicle; the highest point of the line reaches one-half to one inch above the bone. As the first and second parts of the vessel are seldom ligatured, only the anatomy of the third part will be considered. The third part of the artery extends from the outer border of the scalenus anticus to the outer border of the first rib. In front of the artery are the clavicle and subclavius muscle if the shoulder is raised, otherwise the vessel is comparatively superficial. Crossing in front also are the following structures, the termination of the external jugular vein with its tributaries the transverse cervical, suprascapular, and connection from the cephalic vein, these form a plexus in this region; the nerve to the subclavius muscle crosses from above downwards; the suprascapular artery crosses from within outwards; the subclavian vein lies in front but some way below the level of the artery. Behind are the pleura, scalenus medius, and the portion of the first dorsal nerve which ascends to take part in the brachial plexus. Above the vessel, lie the remaining trunks of the brachial plexus. Below is the first rib against which it may be pressed to prevent hæmorrhage.

Position.—The patient lies on the back with the shoulders raised and the head extended and turned to the opposite side. The arm is by the side and pulled well down. The operator may stand by the shoulder or by the head of the patient; the former position is better on the right side and the latter on the left.

Operation.—The skin is drawn down over the clavicle and an incision is made three inches long over the middle portion of the bone. As a rule the incision extends from the attachment of the sterno mastoid to that of the trapezius. The incision divides the superficial fascia and the supraclavicular nerve, the platysma and possibly a vein continuing up the course of the cephalic to the neck. When the skin is released the incision lies about

half an inch above the clavicle. The deep fascia is divided throughout the incision, the termination of the external jugular vein being carefully avoided and hooked to the outside of the wound. The omohyoid muscle is then defined and retracted upwards; below this the outer margin of the scalenus anticus muscle is sought. When the outer border of the scalene muscle has been recognized, the finger should be passed down until the rib is felt. If the finger is then placed in the angle formed by the rib and the outer margin of the muscle with the pulp of the finger directed downwards and backwards, the pulp of the finger must be in contact with the vessel. There is no necessity to feel for the scalene tubercle; in many bones no such prominence exists, and where it does so it is situated on the inner border of the rib. The part of the artery required lies on the upper surface of the rib. By a little dissection the artery should be cleared of its dense fascia, and if any doubt exists in the mind of the operator the first dorsal nerve should be exposed also. The needle should be passed from behind forwards, while the vein is held out of the way with the finger. The needle should pass between the artery and the rib.

Comment.—The operation on the cadaver is much easier than the student is led to believe from accounts of the operation on the living subject. If the operator will avoid tearing, will seek his landmarks in order—the omohyoid, the outer border of the scalanus anticus, and then the angle between the muscle and the rib—he will encounter no difficulty.

In a short, thick-necked individual the wound is deeper and the space is less. The venous plexus is sometimes a great trouble. The dangers are,—wounding the veins, with air embolism as a consequence, or piercing the pleura or the subclavian vein with the needle. A common mistake is to ligature the nerve. After the operation is completed the vessel should be divided and its relation to the nerve clearly demonstrated.

Collateral Circulation.—The posterior and suprascapular with the thoracic axis and subscapular; the internal mammary, and intercostals with the thoracic and scapular branches of the axillary.

INNOMINATE ARTERY

Anatomy.—The vessel is from one and a half to two inches in length, and is marked out by drawing a line from a point on the front of the manubrium sterni just to the right of the middle line on a level with the upper border of the second rib, to the right sterno clavicular articulation. The innominate artery lies behind

the manubrium sterni, being separated from the bone by the following structures: the origins of the sterno-hyoid and sterno-thyroid muscles, the fatty remains of the thymus gland and the termination of the left innominate vein. On the right side lie the right innominate vein, which rather overlaps the artery in front, the right vagus nerve, and the mediastinal layer of the right pleural sac. On the left side are from below upwards the right common carotid artery, the inferior thyroid veins and the trachea. The vessel in rare instances gives off a thyroidea ima branch.

Position.—The position is the same as in the previous operation.

Operation.—An incision is made along the anterior border of the lower part of the sterno-mastoid. A second incision is made from the lower end of the first along the upper border of the inner end of the clavicle. Both incisions are about three inches in length. The flap is dissected up and the sterno-mastoid muscle divided close to its origin. The anterior jugular vein is secured as it passes outwards behind the muscle. The sterno-hyoid and sterno-thyroid muscles are then divided. The deep layer of the cervical fascia is opened and the right common carotid artery made out and its sheath opened low down. By following down this vessel the bifurcation of the innominate will be found. The innominate must be cleared with the utmost care to avoid injury to the large veins and the pleura or including the vagus. This is the most difficult part of the operation. The needle is passed from without inwards. To avoid the danger of secondary hæmorrhage from the distal end, it is customary to ligature the common carotid and vertebral arteries at the same time. The student should always do this in the dead body. In ligaturing vessels of this size a double ligature and stay knot should be used.

THE VERTEBRAL ARTERY

Anatomy.—This artery arises from the first part of the subclavian on the inner side of the scalenes anticus. It passes upwards and backwards between that muscle and the longus colli, to the foramen in the transverse process of the sixth cervical vertebra. It is surrounded by a plexus of sympathetic nerves and covered anteriorly by the vertebral and the internal jugular veins. The vessel is crossed by the inferior thyroid artery, and on the left side by the termination of the thoracic duct.

Operation.—An incision three inches in length is made along the lower part of the posterior border of the sterno-mastoid muscle. The muscle is retracted and the wound deepened until the scalenus anticus is defined. The structures of the carotid

sheath are displaced inwards, and the prominent transverse process of the sixth cervical vertebra made out. The artery lies immediately below this process in the interval between the longus colli and the scalenus anticus muscles. The inferior thyroid artery and the vertebral vein are cleared from the front of the vessel, and the needle passed from without inwards. As the ligature is tightened, the pupil on that side contracts owing to the interference with the dilator pupillæ branches of the sympathetic.

Comment.—In class work, as the operation displaces the anatomical arrangements of the common carotid, this vessel is very seldom tied except in conjunction with ligature of the innominate artery.

THE COMMON CAROTID ARTERY

Anatomy.—On the left side of the body the common carotid artery arises direct from the aorta, on the right side it is a branch of the innominate artery. On both sides the vessel terminates opposite the upper border of the thyroid cartilage on a level with the fourth cervical vertebra. The line of the artery is marked by a line drawn from the sterno clavicular articulation, to a point midway between the mastoid process and the angle of the jaw ; this corresponds roughly to the anterior border of the sterno-mastoid muscle. The artery may be compressed against the prominent transverse process of the sixth cervical vertebra, a fact which is made use of by the criminal classes to garrot people. The artery is covered throughout its length by the integuments, platysma, and deep fascia, and overlapped by the anterior edge of the sterno-mastoid. The omohyoid crosses it at the level of the sixth cervical vertebra, and below this level the vessel is more deeply placed, being covered by the sterno-thyroid and sterno-hyoid muscles, and partly by the thyroid body. The anterior jugular vein crosses the lower part transversely, while the middle thyroid vein does so at the level of the sixth cervical vertebra. The inferior thyroid artery and the recurrent laryngeal nerve pass behind it at the same level. Above the omohyoid, the artery is crossed by the superior thyroid veins and sometimes by an artery to the sterno mastoid muscle. The artery gives off no branches. It is enclosed in a strong process of the deep fascia called the carotid sheath. The carotid sheath is divided into three compartments, in the inner one lies the artery, the outer contains the vein which overlaps the artery to a considerable

extent, especially on the right side, while behind and between lies the vagus nerve. Behind the sheath the transverse processes of the vertebræ are clothed by the longus colli muscle, on whch lies the sympathetic nerve.

Position.—The shoulders are raised, the head is extended and turned *slightly* to the opposite side.

Ligature above the level of the Omohyoid

Operation.—The artery is nearly always secured above the omohyoid, as it is much more superficial here than lower down. An incision three inches long is made in the line of the artery; the centre of the incision should be opposite the cricoid. The skin, platysma, superficial fascia, and branches of the transverse cervical nerve are divided. The anterior border of the sterno-mastoid muscle is defined, and along this the deep fascia is divided for the length of the incision. The muscle is drawn outwards, and the omohyoid muscle sought for, passing obliquely upwards and inwards; it may be displaced slightly downwards. In the angle formed by the two muscles the prominent transverse process can be felt. The middle thyroid veins are avoided. The sheath is picked up and divided well on the inner side to prevent opening into the compartment for the vein or wounding the vein itself, this also avoids the descendens hypoglossi nerve, which lies on the anterior surface of the sheath. The artery must be carefully cleared and the needle is passed from the vein.

Ligature below the Omohyoid

This operation is seldom undertaken, even in examinations. The incision is placed altogether below the cricoid, and extends to the sterno clavicular articulation. The steps of the operation are the same as in the last—the omohyoid is seen, it is drawn upwards, the sterno thyroid and sterno hyoid are drawn inwards. The sheath is opened, and the needle passed in the same way.

Comment.—The head must not be turned too far over, or the sterno mastoid will overlap the artery more than is expected, and the anterior border may be missed. The artery is very movable, and is easily displaced by the finger. The vein is thin-walled, and even when not adherent to the fascia, may easily be opened. The artery takes a little time to clear, so the needle should not be used roughly. The sympathetic nerve, the vagus, and the descendens hypoglossi are all liable to be included in the ligature.

EXTERNAL CAROTID ARTERY

Anatomy.—The vessel begins at the level of the upper border of the thyroid cartilage by the bifurcation of the common carotid, and ends opposite the neck of the lower jaw by dividing into the internal maxillary and superficial temporal arteries. The course of the vessel is marked out by the upper part of the line drawn to mark the common carotid. At its origin it lies anterior and rather internal to the internal carotid. In the lower part where the ligature is applied it is comparatively superficial, being covered by the integuments, platysma, cervical fascia, and overlapped by the sterno mastoid muscle. An inch and a half above its origin, it disappears under the posterior belly of the digastric and stylo-hyoid muscles, and enters the parotid gland. Below this the vessel is crossed by the anterior division of the tempero maxillary, the lingual veins, and by the hypoglossal nerve. Internal to the vessel lie the constrictors of the pharynx, the superior laryngeal nerve, the styloid process, the stylo-pharyngeus muscle and glosso-pharyngeal nerve; the last three structures separate the external from the internal carotid. The artery gives off many large branches, and therefore diminishes rapidly in size. The important branches given off are the superior thyroid, immediately at its origin; the lingual, opposite the great cornu of the hyoid bone; and the occipital and the facial, which arise from opposite sides of the vessel almost immediately above the lingual. A distance of about three-quarters of an inch separates the two first-named branches, and in this segment the ligature is applied—this being "the site of election."

Position.—As in the last operation.

Operation.—The great cornu of the hyoid bone is felt, and an incision two and a half inches long is made in the line of the artery, its centre being opposite this point. The incision divides the skin, platysma, superficial fascia, and some of the inframandibular branches of the facial nerve. The anterior border of the sterno mastoid is recognized, and along this the deep fascia is divided. The muscle is retracted and the posterior belly of the digastric is seen in the upper part of the incision. About a quarter of an inch lower down the hypoglossal nerve may be seen crossing transversely. The great cornu of the hyoid bone is again felt for and the vessel recognized immediately posterior to it. It is often obscured by veins at this point, and these must be drawn aside or secured and divided; the sheath is opened and the artery cleared after the position of the superior thyroid and lingual arteries has been ascertained. The needle is passed

from within outwards, avoiding the veins and the superior laryngeal nerve.

Comment.—There are many landmarks to be recognized in the course of this operation, and for this reason the operation sometimes proves difficult. The veins are sometimes a great obstacle. The branches of the artery are very irregular, the lingual and the facial often arising by a common trunk, from which in some cases the occipital and the superior thyroid may also have origin. Occasionally great tortuosity is met with in both the external and internal carotids at their origin. This condition is usually bilateral.

THE LINGUAL ARTERY

Anatomy.—This artery arises as a branch of the external carotid opposite the great cornu of the hyoid bone; it ends as the ranine at the tip of the tongue. It is divided into three parts by the hyoglossus muscle. The first part has a curved course, running forwards, at first upward and then downwards, till it comes to lie immediately above the hyoid bone. This part lies on the middle constrictor of the pharynx. It is here covered by the superficial structures and lymphatic glands, being crossed by the hypoglossal nerve and the facial and lingual veins. It is overlapped by the posterior belly of the digastric and the stylo-hyoid muscles which go to the lesser cornu. The first part of the artery gives off a small inconstant hyoid branch, which runs along the hyoid bone, and a dorsalis linguæ branch, usually double, which runs up to the base of the tongue. The second part of the artery has a short, straight course, lying immediately above the hyoid bone, between the hyoglossus and the genio-hyoglossus muscles. The hypoglossal nerve, after crossing the first part of the artery, is continued forward at a higher level than the artery from which it is separated by the hyoglossus muscle. The ranine vein accompanies the hypoglossal nerve, but the artery is accompanied by two venæ comites.

Position.—The head should be turned on one side and a little more extended than in the preceding operations. The surgeon stands on the side to be operated upon; an assistant steadies the head.

Ligature of the Second Part (beneath the hyoglossus muscle)

Operation.—A curved incision is made, commencing a little below and to one side of the symphysis and ending a little below

and in front of the point where the facial artery crosses the lower jaw. The incision should curve down to the level of the hyoid bone. The superficial structures are divided in the whole length of the incision, and probably a superficial vein must be secured. The submaxillary gland is recognized and the deep fascia incised along its lower margin. The gland is turned out of its bed and retracted upwards against the lower jaw. The layer of fascia on the deep surface of the bed of the gland is now divided, and certain structures must be clearly defined.

These structures are as follows: The two bellies of the

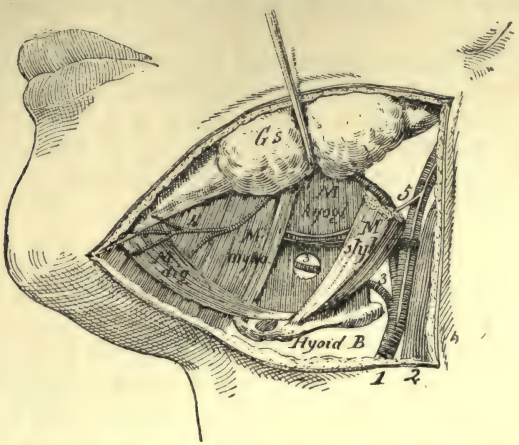


FIG. 19.—LIGATURE OF THE LINGUAL ARTERY.
(Rose and Carless.)

The submaxillary gland (Gs) has been drawn over the side of the jaw with a hook. 1, External carotid. 2, Internal jugular artery. 3, Lingual artery. 4, Ranine branch of facial artery. 5, Hypoglossal nerve. M. dig, digastric. M. styl, stylo-hyoid. M. myho, mylo-hyoid. M. hyogl, hyoglossus. The place where the artery is tied is indicated by a window in the hyoglossus, through which it can be seen.

digastric, the posterior border of the mylohyoid, the hyoglossus muscle, with the several structures lying upon its surface. The anterior and posterior bellies of the digastric have already been recognized, their fibres lie almost parallel with the curved lower margins of the wound. The assistant draws the intermediate tendon towards the surface with a blunt hook. The posterior border of the mylohyoid is seen in the anterior part of the wound. The floor of the wound behind this muscle is formed by the vertical fibres of the hyoglossus. Lying upon the surface of the hyoglossus muscle and disappearing in front under cover of the mylohyoid, are, from above downwards, the deep part of the subaxillary gland, the hypoglossal nerve, and in all probability the ranine vein. If an assistant with a hand under the neck

pushes the hyoid bone up towards the operator, the field of operation comes nearer the surface, and the manipulations are easier to perform. In the triangle formed by the two bellies of the digastic below and the nerve above, a transverse incision, one-third to one half an inch long, is made through the hyoglossus muscle. This incision lies one-quarter of an inch above the hyoid bone. The muscle is divided cautiously, and the artery bulges out of the opening and is easily recognized. The needle is passed from above downwards.

Comment.—The operation is frequently performed both in the living and on the cadaver, and, owing to the respect with which it is approached, mistakes through carelessness are uncommon. A correct anatomical knowledge is essential. The operation should be performed methodically, the gland turned well up to obtain room and to allow a clear view. Not infrequently the gland is cut into by mistake. The three muscles must be recognized and the nerve demonstrated.

Ligature of the First Part

This operation is seldom performed on the dead body, and though theoretically better, in practice little inconvenience is experienced from applying the ligature on the distal side to the dorsalis linguæ branches. There is more uncertainty about applying a ligature to the first part, as the method and place of origin are subject to wide variations.

Operation.—The operation is performed through the same incision as is used for the external carotid ; the steps are the same, and the artery in question is not infrequently exposed during that procedure. The hypoglossal nerve is drawn upwards from where it crosses the artery and the needle is passed from the nerve. The chief difficulty encountered is from the presence of the veins which lie superficial to this part of the artery.

THE FACIAL ARTERY

It is unnecessary to give the anatomical details of this vessel. It may be ligatured at the neck through the same incision used for exposing the external carotid and the first part of the lingual. More commonly it is secured where it crosses the lower jaw.

Operation.—The position of the artery on the lower jaw is felt immediately in front of the insertion of the masseter. The skin is pulled upwards (so that later the scar will be under cover

of the jaw), and an incision one inch long is made on the bone transversely to the line of the vessel. Care must be taken that the vessel is not divided at the first incision. The artery is easily exposed with the vein lying immediately behind it. The needle should be passed from the vein.

THE TEMPORAL ARTERY

This vessel is usually ligatured as it crosses the root of the zygoma, here it is only covered by the ligaments and a very strong fascia.

Operation.—A vertical incision one inch long is made in the line of the vessel with the mid point opposite the root of the zygoma. This is gradually deepened, and any twigs of the tempero-facial nerve are drawn to one side. The artery is easily exposed. The vein lies behind and overlaps the artery. The auricular temporal nerve lies in front. The needle may be passed from the vein or from the nerve.

THE OCCIPITAL ARTERY

This may be secured at its origin from the external carotid, through the same incision as is used to expose the larger vessel. The hypoglossal nerve is recognized and followed back to the point where it hooks round the occipital artery. In the cadaver it is more usual to expose the second part of the artery.

Operation.—An incision two and a half inches long is made backwards and slightly upwards from the tip of the mastoid process. The superficial structures are divided and the posterior part of the insertion of the sterno-mastoid muscle exposed. This must be severed freely and the splenius capitis brought into view to be divided in turn. The trachelo-mastoid muscle is next exposed, and is similarly dealt with. The margins of the wound are retracted, and the finger defines the space between the mastoid process and the transverse process of the atlas. The artery is exposed as it appears from under the origin of the posterior belly of the digastric muscle, lying close to the bone. The needle is passed in the direction that is found most convenient. The emissary vein from the mastoid opens into the veins of the vicinity which, therefore, should not be wounded.

THE INTERNAL MAMMARY ARTERY

Anatomy.—This artery is a branch of the first part of the subclavian artery, it ends behind the sixth costal cartilage by dividing into the musculo-phrenic and the superior epigastric arteries. From the first to the sixth rib, the vessel descends about half an inch from the lateral margin of the sternum. Behind the vessel in the upper part of its course is the pleura, lower down it lies on the digitations of the triangularis sterni muscle. On the left side, in the fourth and fifth interspaces, there is no pleura between it and the tissues of the anterior mediastinum. In front are the digitations of the pectoralis major, costal cartilages, anterior intercostal apponeurosis, the internal intercostal muscle, and the terminations of the intercostal nerves. The artery is accompanied by two venæ comites. In each space, a little to the inner side of the line of the artery, a small anterior branch comes to the surface in company with the terminal branch of the intercostal nerve.

Operation.—A transverse incision one and a half inches long is made from the lateral margin of the sternum so as to lie midway between two costal cartilages. The fibres of the pectoralis major are separated and retracted. The anterior intercostal apponeurosis is exposed and the anterior perforating vessels and nerve seen coming towards the surface. The apponeurosis is divided in the length of the incision, the structures just mentioned being carefully avoided as they serve as a guide to the vessel. The internal intercostal muscle is divided in the same way. The artery is now identified in the depths of the wound. The nerve is drawn to one side, and the needle passed from without inwards.

Comment.—There is plenty of room to tie the artery in the upper three spaces, and sometimes also in the fourth space, the fifth space is too narrow. In the upper spaces the vessel is larger than in those below. Great clumsiness must be exercised to wound the pleura.

CHAPTER III

Operations on Nerves

Preliminary remarks—Operations on nerves of the upper and lower limbs—Operations on nerves of the head and neck.

OPERATIONS ON NERVES

Preliminary Remarks.—As in the case of the operations for ligature of arteries, the operations on the nerves described here are mostly of the dissecting-room variety, performed to display anatomical knowledge and to demonstrate the candidate's skill in handling his instruments.

Operations on nerves are seldom called for, but may be required for the following reasons:

1. Trauma, which directly or indirectly involves the nerve. A cut at the wrist dividing the medium or the ulnar illustrates the former, while the implication of the musculo-spiral in the callus of a fractured humerus instances the latter.

2. Perversion of function, either sensory as in neuralgia, or motor as in spasmodic wry-neck.

3. Neoplasms, in connection with the nerve itself, or which by invading the nerve cause severe pain.

The following operations are performed on nerves to meet these contingencies:—

1. Suture (neuroraphy) of the divided nerve trunk, or anastomosis.

2. Nerve stretching.

3. Division of the nerve (neurotomy), or removal of a portion of the nerve (neurectomy).

4. Injection of fluids.

Suture of a Divided Nerve

In all cases where a wound is sustained in a position where an important nerve is liable to injury, steps should be taken at once to ascertain the condition of the nerve before closing the wound.

Primary Suture is the term applied when the two ends of the nerve are sutured together within a comparatively short time of the receipt of the injury. It is therefore performed in the original wound. The wound is cleaned and rendered aseptic. The ragged ends of the nerves are exposed and the bruised tissue removed. The ends are then brought together and fixed in apposition with fine catgut suture. The wound is then partially closed and the part immobilized upon a splint.

Secondary Suture is the term applied when the ends are united after a considerable period has elapsed since the injury. The operation is as follows :—

1. *Exposure of the ends of the nerve.*—An incision is made over the line of the nerve, its centre being opposite the place of injury. The length of the incision varies with the position of the nerve and in many cases has to be prolonged later. The ends of the nerve may be separated to the extent of an inch and are embedded in scar tissue, or it may be in callus. The proximal end should be found first as it gives some indication of the probable position of the distal portion. This end is bulbous and little difficulty is experienced in finding it, sometimes it can be located beforehand by its sensitiveness. The distal extremity is atrophied, and the attenuated end may be lost in cicatricial tissue and be very difficult to find. If this be the case, the incision should be prolonged downwards clear of the scar tissue, and the nerve trunk found in its normal anatomical position. It can then be traced up and the end secured.

2. *Paring the ends.*—The two ends are carefully pared. Only the extremity of the lower end need be removed, but a generous slice, including the major portion of the bulb, should be cut from the proximal end.

3. *Suture of the ends.*—This may be done by catgut or silk, the former for choice, threaded on flat or round pointed needles. The sutures easily cut out and to avoid this they should be passed twice through the whole thickness of the ends, about a quarter of an inch from the cut surfaces. Several sutures are passed before any are tied. The limb is then held in the position which brings the ends most readily together and all the sutures are tied. Additional sutures are added if required. The wound is then closed and fixed in a suitable position by a splint. In cases where the ends can not be brought together, the interval may be bridged by numerous strands of catgut along which the nerve fibres may grow. Other methods recommended are transplantation of nerve or spinal cord of a rabbit.

Comment.—Needless to say, primary suture is both easier of

performance and better in its results. In both cases sensation returns before motion.

1. **Nerve Anastomosis.**—This is sometimes performed where the facial nerve has been destroyed from middle ear disease. The distal portion having been exposed and the end freshened, either the spinal accessory or the hypoglossal nerves are brought to the surface. All or part of the nerve chosen is sutured to the distal portion of the facial nerve. Anastomosis with the spinal accessory is said to give the better result.

2. **Nerve Stretching.**—This is performed for the relief of pain in neuralgias or for the treatment of wry-neck. Good results have been obtained both in sensory and motor troubles. Perhaps the best are seen after stretching the sciatic for sciatica or the supra-orbital in recurrent neuralgia. The steps of the operation are described in dealing with the several nerves.

3. **Neurectomy and Neurotomy** have been employed with equal success in similar cases, but their use is limited to the smaller sensory and the less important motor nerves.

4. **The injection of fluids** into and around the nerve sheath has been tried with success in cases of neuralgia. Distilled water is injected into a large mixed nerve like the sciatic, one or two drams being injected into the sheath of the nerve at two or more points. A syringe with a long needle must be used as the nerve lies at a considerable depth. Pure alcohol is used to produce more lasting effects on sensory nerves, such as the branches of the trigeminal.

Great accuracy is essential in performing the operation as the alcohol should be injected into the nerve immediately after it emerges from the skull. The ophthalmic and the superior maxillary divisions may both be reached by entering the syringe just below and behind the middle of the lower border of the malar bone. The needle is thrust upwards, backwards and inwards for the required distance, which must be ascertained carefully beforehand. This precaution is most important, as there is considerable danger of injecting and destroying the optic nerve, which lies in close proximity to these two structures.

Another method of reaching the foramen rotundum is to enter the needle at the outer canthus of the orbit and pass it back through the speno-maxillary fissure across the pterygo-maxillary fossa.

To reach the inferior maxillary division at the foramen ovale, the lower jaw must be opened widely to displace the coronoid process; the needle is entered below the middle of the zygoma and thrust through the coronoid notch to the base of the skull.

After a successful injection there should be complete anæsthesia of the skin supplied.

OPERATIONS ON THE NERVES OF THE EXTREMITIES

THE ULNAR NERVE

Anatomy.—The course of this nerve may be marked on the arm by taking a point immediately posterior to the brachial artery in the middle of the upper arm and joining this to the groove on the back of the internal condyle. The nerve is here accompanied by the inferior profunda vessels. Above this point the nerve lies to the inner side of the artery (Fig. 20). The line of the nerve in the forearm is marked by a line drawn from the groove behind the internal condyle to the outer border of the pisiform bone. The nerve lies deeply in the upper part of the forearm but is superficial at the wrist, being in front of the anterior annular ligament to the inner side of the artery. The

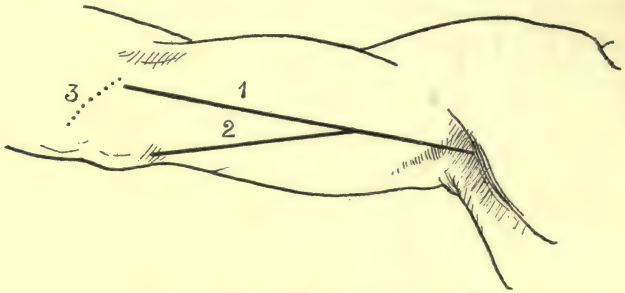


FIG. 20.—SURFACE MARKING OF ARM.
1, Line of median nerve. 2, Line of ulnar nerve. 3, Bicipetal fascia.

nerve supplies 1½ muscles in the forearm and 15½ in the palm; it supplies sensation to the inner part of the hand, and the inner 1½ digits both on their dorsal and palmar aspects.

The nerve may be exposed at any part of its course, but is usually operated upon at the wrist, the elbow, and sometimes in the upper arm.

(1) In the lower third of the forearm (above the wrist)

Operation.—The nerve is exposed at this point through the same incision as is used to apply a ligature to the ulnar artery in this situation. The nerve lies immediately to the inner side of the vessel.

(2) Behind the elbow

Operation.—The groove on the posterior and under aspects of the internal condyle is defined. An incision 1½ inches long is made in the line of the nerve a little above this groove. The nerve lies behind the internal intermuscular septum and is accompanied by the inferior profunda vessels and the posterior division of the anastomotica magna.

(3) Above the middle of the upper arm

Operation.—An incision is made as if for the brachial artery and the nerve is found on the inner side of the vessel.

THE MEDIAN NERVE

Anatomy.—The line of the nerve in the upper arm is the same as the line of the brachial artery, which structure it accompanies and crosses from without inwards about its middle. In the forearm a line drawn from the middle of the front of the elbow to the interval between the tendons of the flexor carpi radialis and the palmaris longus muscles (or in the absence of the latter to the inner side of the former) will mark the course of the nerve. In the forearm it lies between the superficial and the deep flexors, it enters the hand behind the anterior annular ligament.

The nerve supplies directly or indirectly through its branch the anterior interosseous, all the muscles (6½) on the front of the forearm with the exception of the flexor carpi ulnaris and half the flexor profundus digitorum, which are supplied by the ulnar; it also supplies four and a half muscles in the palm of the hand, and the skin of the outer part of the front of the palm and the three and a half outer digits.

(1) In the lower third of the forearm

Operation.—The nerve is readily exposed at this level by an incision one and a half inches long placed parallel to and immediately to the inner side of the tendon of the flexor carpi radialis. The deep fascia is divided, the tendon displaced a little outwards and the nerve is seen. Occasionally an enlarged comes nervi mediani artery is found replacing either the radial or the ulnar vessels.

(2) In the upper arm

Operation.—Here the nerve is exposed through an incision over the line of the brachial artery, the nerve crossing in front

of the artery from without inwards about the middle of this segment of the limb.

THE MUSCULO SPIRAL NERVE

Anatomy.—This, the largest nerve of the brachial plexus, is the continuation of the main part of the posterior cord. The course of the nerve may be marked on the surface by a line drawn from the tendon of the teres major round the back of the limb to a point midway between the insertion of the deltoid and the external condyle of the humerus and thence downwards to the front of the external condyle. The nerve lies behind the termination of the axillary artery and upper part of the brachial, which it separates from the long head of the tricepa. It passes round the back of the humerus in the musculo-spiral groove accompanied by the superior profunda vessels. On the outer side of the arm

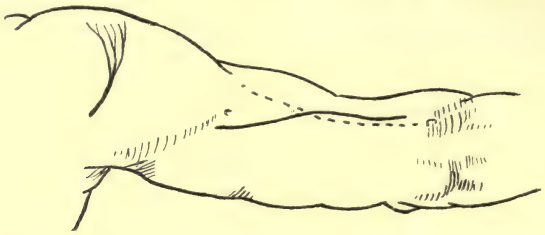


FIG. 21.—MUSCULO SPIRAL AND CIRCUMFLEX NERVES.

it pierces the external intermuscular septum to reach the anterior compartment of the limb, and lies deeply between the brachialis anticus to the inner side and the supinator longus to the outer side. The nerve supplies directly or indirectly through its branch, the posterior interosseous, all the muscles on the back of the upper arm and forearm, together with the outer half of the brachialis anticus (13½). It supplies sensory branches to the back and outer side of the upper arm, to an area running down the middle of the back of the forearm, to the backs of the hand and the three outer digits.

The nerve is usually exposed as it lies between the brachialis anticus and the supinator longus on the outer side of the arm.

Operation.—An oblique incision, two and a half inches long, is made in the line of the nerve from a point midway between the insertion of the deltoid and the external condyle. This incision should correspond to the anterior border of the supinator longus muscle. The deep fascia is divided and the finger seeks the

intermuscular space to the inner side of the supinator longus. The space is opened up and the nerve discovered lying close to the bone.

Comment.—To expose the nerve when involved in callus after fracture of the humerus, an incision is usually made down the back of the upper arm at the level of the fracture. The fibres of the triceps muscle are separated longitudinally and the callus exposed. The nerve is demonstrated entering the callus above and is freed from above downwards. Muscular tissue is usually interposed between the nerve and the callus to prevent its becoming pressed upon again.

The operations on nerves of the lower extremities are confined to the great sciatic nerve and its branches, the internal and external popliteal nerves, and it is convenient to consider them in this order.

THE GREAT SCIATIC NERVE

Anatomy.—This is the largest nerve in the body ; it is flattened from before backwards and extends from the sacral plexus down to the middle of the thigh, where it ends by dividing into its internal and external popliteal branches. The nerve and its branches may be marked on the surface as follows. A point is taken a little internal to the mid point between the great trochanter and the ischial tuberosity, and from this a line is drawn down to the middle of the back of the calf, on a level with the tubercle of the tibia. The great sciatic is marked out by the upper and the internal popliteal by the lower half of this line. If the line is prolonged to the interval between the prominence of the heel and the internal malleolus, the course of the posterior tibial nerve will be represented. The external popliteal nerve is marked by a line drawn from the great sciatic nerve at the middle of the thigh to a point one inch below the head of the fibula. The small sciatic nerve lies in the same line as the great, but is superficially placed.

The great sciatic nerve has in front of it, from above downwards, the tricipital tendon, the quadratus femoris and the adductor magnus muscles. The nerve is deeply placed, being covered above by the gluteus maximus and below by the long head of the biceps.

The nerve is usually exposed immediately below the gluteus maximus.

Position.—The patient lies over on the face, the surgeon stands on the outer side of the limb operated upon ; some operators prefer to stand on the opposite side of the body.

Operation.—The line of the nerve is marked out and the lower margin of the gluteus maximus defined. An incision four inches long is made precisely in the line of the nerve starting from just above the lower margin of the gluteus maximus. The superficial and deep fascia are divided and the lower margin of the gluteus is retracted upwards. The hamstrings are seen just below their origin. They should be relaxed by bending the knee; the muscles are then drawn to the inner side. The great sciatic nerve may be seen in the depths of the wound. If it is not seen the finger should be inserted and hooked towards the hamstrings on the inner side, the nerve will be found on the finger. This manœuvre is easier to perform from the opposite side of the body, and for this reason some surgeons prefer to stand on that side or to change over during the operation. The nerve is drawn to the surface and stretched by steady traction for three to five minutes, no jerking should be allowed. The nerve will stand with safety a pull which will just lift the limb off the table. The nerve is replaced and the wound closed.

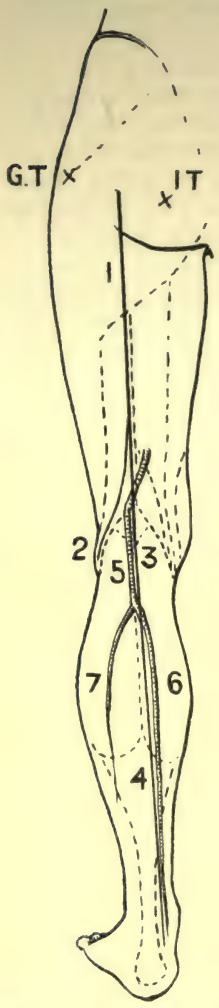


FIG. 22.—SURFACE MARKING OF LOWER LIMB.

GT, Great trochanter. IT, Ischial tuberosity. 1, Great sciatic. 2, External popliteal. 3, Internal popliteal. 4, Posterior tibial nerves. 5, Popliteal artery. 6, Posterior tibial artery. 7, Peroneal artery.

THE INTERNAL POPLITEAL NERVE

Anatomy.—The chief points in the anatomy of this nerve have been given when dealing with the popliteal artery, its surface marking is given with the preceding nerve.

Position.—The patient lies in the semi-prone position with the limb extended.

Operation.—A vertical incision two and a half inches long is made over the centre of the popliteal space. The integuments are divided and the short or external saphenous vein and the termination of the small sciatic nerve are displaced outwards. The deep fascia is incised. The two heads of the gastrocnemius

are exposed and the interval between them opened up with retractors. The sural vessels and nerves of supply will be seen entering the two heads of the muscle. By feeling in this interval the cord-like nerve is easily made out, the short saphenous vein dips down to its outer side. The structures may be relaxed by placing a block under the foot.

THE EXTERNAL POPLITEAL NERVE

Anatomy.—This nerve is slightly smaller than the last and lies under cover of the upper and outer boundary of the popliteal space. It follows the biceps muscle downwards over the outer head of the gastrocnemius, and can be felt winding round the neck of the fibula fully one inch below the insertion of the biceps. The surface marking is given with that of the great sciatic. The student should be able to identify the nerve, the tendon of the biceps, and the posterior edge of the ilio-tibial band on the outer aspect of the knee joint.

Operation.—After defining the tendon of the biceps, an incision one and a half inches long is made parallel to and immediately behind this structure. The incision should reach down to the level of the head of the fibula. The deep fascia is incised and the tendon exposed and hooked to the outer side. The nerve is easily seen.

OPERATIONS ON THE NERVES OF THE HEAD AND NECK

The Ophthalmic Division of the Fifth Nerve

Anatomy.—The supra orbital nerve leaves the orbit through the supra-orbital notch which is situated at the junction of the inner and middle thirds of the upper boundary of the orbit. The nerve divides almost at once into inner and outer divisions, the latter and larger of the two extends back almost to the lambdoidal suture. The nerve is accompanied by the supra-orbital vessels which lie to its outer side.

Operation.—The eyebrow being shaved the position of the notch is ascertained. The eyebrow is drawn up and an incision three-quarters of an inch long made transversely to the line of the nerve. The fibres of the orbicularis palpebrarum are divided and the nerve exposed, lying close to the bone. The nerve is isolated from the vessels and is stretched or divided. A considerable part of the distal portion of the nerve can be removed

by gripping it at right angles with artery forceps and then twisting the instrument so as to wind the nerve round the blades.

The Second Division of the Fifth Nerve

Anatomy.—This nerve leaves the skull through the foramen rotundum, crosses the spheno-maxillary fossa obliquely, being connected at this point with Meckel's ganglion. It then enters

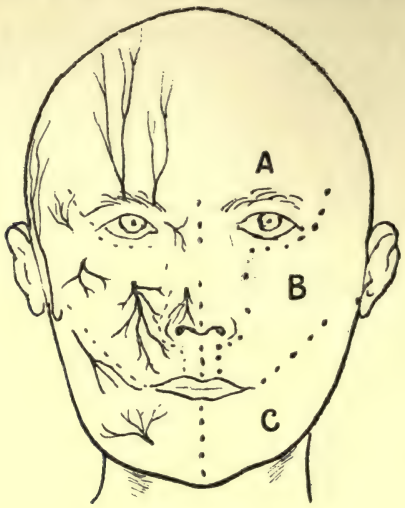


FIG. 23.—NERVE SUPPLY OF FACE.

The right side of the face shows the portions developed from A the fronto nasal, B the maxillary, and C the mandibular processes. The left side shows the distribution of the corresponding three divisions of the fifth nerve.

the infra-orbital groove, which later becomes a canal, and emerges at the face of the infra-orbital foramen a quarter of an inch below the orbital margin. The distance between the foramen rotundum and the infra-orbital foramen is about two inches. If a line be drawn from the supra-orbital notch down through the interval between the two bicuspid teeth of the lower jaw, the points of emergence of the supra-orbital, infra-orbital, and the mental nerves will all be found along this line. The branches of the nerve and its connections with Meckel's ganglion are shown in Fig. 24. It should be noted that the orbital branch comes off before the ganglion, but that the dental nerves all come off after that point. The internal maxillary artery ends to the outer side of the ganglion and branches of the vessel accompany many of the nerves.

1. THE INFRA-ORBITAL NERVE

Operation.—A transverse incision is made three-quarters of an inch long, immediately above the spot where the foramen can be felt.

The orbiculoris muscle is divided and the bone exposed. The lower margin of the wound is displaced downwards, to expose the foramen, and the nerve is seen issuing and can be hooked up. The nerve is isolated from the vessels and stretched or divided.

FIG. 24.—DIVISION OF THE FIFTH NERVE.

Comment.—If the incision is over or below the foramen the nerve may be divided before it is recognized, or the wounded vessels may obscure the field of operation.

2. SUPERIOR MAXILLARY NERVE AND MECKEL'S GANGLION

Operation.—Here the trunk of the nerve is divided as close to the foramen rotundum as possible.

A V-shaped incision, with the point downwards, is made on the front of the face so as to enclose the infra-orbital foramen. The soft parts are divided down to the bone and the flap dissected up and held retracted over the eye. The nerve is secured by a silk ligature as it emerges from the foramen. The anterior wall of the antrum is now removed with a three-quarter inch trephine or with a chisel. The posterior wall of the antrum is now seen and a quarter-inch trephine is applied to the upper and back part, or the chisel may again be used.

The thin under margin of the infra-orbital canal is then broken down with a probe, the ligatured nerve serving as a guide along which to work. The nerve can now be seen disappearing into the spheno-maxillary fossa. It is cleared as far back as possible so as to get behind Meckel's ganglion. Then drawing the nerve forward by the ligature it is divided by a fine curved pair of scissors as near to the foramen rotundum as possible. Some branches of the internal maxillary artery may be divided

FIG. 25.—OPERATIONS ON THE FIFTH NERVE.

1, Supra-orbital nerve. 2, Infra-orbital nerve. 3, Incision to expose Meckel's ganglion.

as this is being done, but the hæmorrhage is soon stopped by firm plugging. The wound may then be closed.

Comment.—The operation is difficult on account of the depth and limited space of the wound, and the hæmorrhage which obscures the view ; it is impossible without a good light, a head lamp is best, but a lamp and reflector will serve. The benefit of the operation for trigeminal neuralgia is in almost all cases of a temporary kind.

The Third Division of the Fifth

Anatomy.—The relationships of the trunk of the nerve need not be detailed ; the branches which are concerned in the operations below are the mental, the inferior dental, and the lingual. The inferior dental and the lingual are derived from the posterior division of the nerve.

They lie at first on the inner surface of the external pterygoid muscle, behind the posterior border of the internal pterygoid and in front of the middle meningeal artery. The internal maxillary artery passes forwards on the outer side of these nerves.

The inferior dental nerve is the larger and more posterior of the two ; it descends to the interval between the ramus of the jaw and the spheno-mandibular ligament in company with the inferior dental artery. The two structures enter the inferior dental canal opposite the middle of the ramus and run in the substance of the bone, giving off branches to the teeth. Just before entering the canal the nerve gives off the branch to the mylo-hyoid muscle, and opposite the canine tooth the mental branch recurs to appear on the face through the mental foramen, the direction of which is backwards and upwards.

The lingual nerve lies at first in front and to the inner side of the inferior dental. It descends on the inner side of the external pterygoid, then between the internal pterygoid, and the ramus of the jaw, to the posterior part of the mylo-hyoid ridge, where it lies under the mucous membrane below the last molar tooth ; in this situation it can be felt from the mouth. It then lies on the fibres of the superior constrictor to reach the side of the tongue crossing the outer surfaces of the stylo-glossus, hyo-glossus and genio-hyoglossus muscles. The connections made by the nerve with the chorda tympani, the sub-maxillary ganglion, and the hypoglossal nerves should be recalled.

1. THE MENTAL NERVE

Operation.—The lower lip is drawn down and an incision one inch long made opposite the lower bicuspid teeth in the reflection of mucous membrane from the cheek on to the gum. The tissues are divided till the mental foramen is felt. The foramen is then exposed and the nerve isolated.

2. THE INFERIOR DENTAL NERVE IN THE LOWER JAW

In this operation the nerve is exposed, lying in the inferior dental canal. The centre of the trephine is the point of intersection of two lines, one prolonging the alveolar margin backwards, the other passing vertically upwards from the angle of the jaw.

Operation.—A horizontal incision, one and a quarter inches long, is made over this point, so as to lie parallel to the fibres of the facial nerve. This incision lies well below the line of the parotid duct. The coarse fasiculi of the maseter are exposed and

split in a vertical direction, the bone below being cleared with a raspatory. The margins of the wound are retracted and a half-inch trephine applied to the bone. The outer table of the bone is cut through and removed with an elevator. The inferior dental canal containing both nerve and artery is exposed. The nerve is isolated and divided high up, and the distal end with-

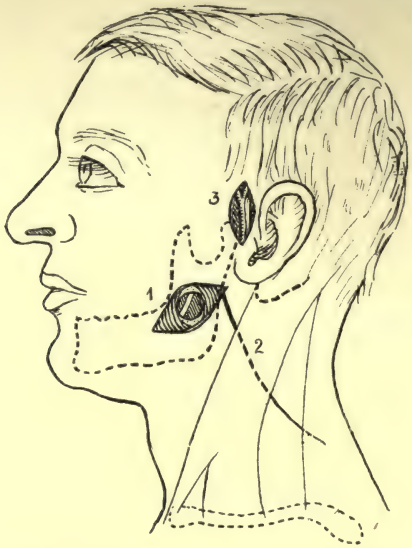


FIG. 26.—OPERATIONS ON THE FACE.

1, Inferior dental nerve exposed through a trephine hole in mandible. 2, Line of spinal accessory nerve. 3, Incision for the temporal artery, (the outlines of the mandible, mastoid and clavicle, are dotted in).

drawn by twisting it round a pair of artery forceps. The disc of bone is not replaced.

Comment.—The operation is easy, and the relief from pain is often immediate, but recurrence is almost certain in one to three years. If the operation is placed at a higher level so as to lie above the entrance to the canal, both tables of the bone must be cut through and both the lingual and the inferior dental nerves may be exposed at the lower border of the external pterygoid muscle.

3. THE LINGUAL NERVE

Operation.—This is usually divided from the interior of the mouth.

The mouth is gagged open, the cheek retracted and the tongue drawn to the opposite side. The nerve is felt for below and behind

the last molar tooth. An incision one inch long is made through the mucous membrane over the position of the nerve, which is exposed at once. It is drawn forward on a hook and a piece excised.

THE GASSERIAN GANGLION

Anatomy.—The Gasserian ganglion lies in the cavum Meckelii, a cleft of dura mater above a depression on the inner part of the upper surface of the petrous portion of the temporal bone Above lie the superior petrosal sinus, below is a branch to the ganglion from the internal carotid, and the motor root of the fifth going to the foramen ovale. The inner end of the ganglion is in close relation to the cavernous sinus and the internal carotid artery. The first division of the fifth nerve leaves the ganglion to enter and break up in the outer wall of the cavernous sinus on its way to the sphenoidal fissure. This division is not divided. The second division proceeds forwards to the foramen rotundum. The third division passes almost directly downwards to the foramen ovale and is joined by the small motor root, it is quite impossible to divide the one completely without dividing the other. Just behind and external to the foramen ovale lies the foramen spinosum transmitting the middle meningeal artery.

Instruments.—In addition to the instruments used in trephining operations, a broad flat retractor to displace the dura and brain, long-handled dissecting forceps, an aneurysm needle with a small curve, and a blunt-pointed tenotome are all needed. A suitable light is essential.

Position.—The patient lies on the back with the head and shoulders slightly raised to lessen the hæmorrhage; the head is turned to the sound side.

Operation.—A rounded flap is marked out, its extremities being situated immediately above the ends of the zygoma, while its highest limit should be at least two inches above that process of bone.

The incision divides everything down to the bone, and the flap is raised by means of a periosteal elevator. A disc of bone is removed with a trephine, and with biting forceps the remainder of the exposed bone is cut away.

The dura mater is now raised from the floor of the skull and retracted upwards with a broad retractor. The first branch reached is the third division of the fifth, leaving through the foramen ovale. In defining this, the middle meningeal artery may be in the way and have to be secured. By working forwards from this point, the foramen rotundum is reached with the second

division of the fifth. The dura mater is dissected off the upper surface of these two nerves and the cavum Meckelii opened exposing the ganglion. The second and third divisions of the nerve are divided near the foramina and the ganglion itself cut across transversely immediately below the level of the first division. This must be done by long-handled dissecting forceps and a blunt-pointed tenotome or a pair of fine, long-handled scissors. The position of the cavernous sinus and the oculomotor nerve must be kept in mind. The dura is then released and the flap of superficial tissues sewn up. The bone is not replaced.

Comment.—The constant oozing makes the operation tedious, and pauses have to be made while the wound is plugged to stay the hæmorrhage. The ligature of the middle meningeal is a difficult procedure.

The old method of approaching the ganglion from below, the pterygoid route, is quite given up. There is no necessity to divide and displace the zygoma.

It is now recognized that there is no need to divide the ophthalmic division of the fifth nerve, and the unfortunate complications of ulceration and sloughing of the cornea are thus avoided. Should the ophthalmic division be divided by mistake, the eyelids must be sewn together for some weeks so as to prevent irritation of the eye. The cornea will, however, always remain anæsthetic and foreign bodies will therefore be a constant form of danger.

THE SEVENTH NERVE

Anatomy.—Immediately after emerging from the stylo-mastoid foramen the seventh nerve runs forwards and outwards, to lie superficial to the ramus of the jaw. It bends round to the outer side of the styloid process, where it comes into relation with the posterior auricular artery above the stylo-hyoid and digastric muscles, and then enters the substance of the parotid gland superficial to the external carotid artery. In the gland the nerve breaks up into the pes anserinus. The nerve can be felt in thin people as it crosses the posterior border of the ascending ramus of the jaw immediately in front of the lower part of the tragus.

Operation.—An incision is made starting from half-way down the anterior margin of the mastoid process, downwards and forwards, to the angle of the jaw.

The deep fascia is divided and the interval between the sterno-mastoid muscle and the parotid gland opened up by drawing these two structures aside. The stylo-hyoid muscle and the

posterior belly of the digastric are exposed. The nerve is found immediately above these muscles, and must be isolated from the posterior auricular vessels.

Comment.—The capsule of the parotid should not be injured or troublesome oozing will result.

THE SPINAL ACCESSORY NERVE (Fig. 26)

Anatomy.—The eleventh nerve leaves the skull in company with the tenth nerve, and then lies between the internal carotid artery and the internal jugular vein. It passes downwards in front of the transverse process of the atlas and backwards, superficial to the internal jugular vein, under cover of the stylo-hyoid and the posterior belly of the digastric muscles. The nerve enters the deep surface of the sterno mastoid muscle at a point two inches below the tip of the mastoid process and emerges again half-way down the posterior border of the muscle, crosses the posterior triangle of the neck to the under surface of the trapezius. The course of the nerve is marked by a line drawn at right angles to the middle point of a line joining the tip of the mastoid to the angle of the jaw.

Operation.—An incision two and a half inches long is made from the tip of the mastoid process downwards, along the anterior border of the sterno mastoid. The incision is deepened and the anterior edge of the muscle defined and retracted, the head being bent a little to relax the muscle. The lower margin of the posterior belly of the digastric muscle is next made out. The nerve emerges from under cover of this at right angles to the muscle. The prominent transverse process of the atlas should now be sought. If the finger is placed upon the front of its tip, one may be quite sure that the nerve lies beneath the finger and between it and this process of bone. On pulling the sterno-mastoid forcibly back the nerve can be seen and then defined.

THE HYPOGLOSSAL NERVE

This nerve can be reached through the same incision as is used for applying a ligature to the external carotid artery, its anatomical relations are mentioned when dealing with this artery and its lingual branch.

NOTE.—Through an incision three and a half inches long made from in front of the mastoid process, along the anterior border of the sterno-mastoid, the facial, spinal accessory, and hypoglossal nerves can all be exposed and if necessary, an anastomosis performed between the seventh and one of the other two.

THE BRACHIAL PLEXUS

Anatomy.—This plexus is formed by the lower four cervical and first dorsal nerves. It may be marked on the surface by a triangle with its apex on the outer side of the first part of the axillary artery. The base of the triangle extends from just above the prominent transverse process of the sixth cervical vertebra vertically downwards to the clavicle.

Operation.—The plexus is best exposed by an incision, one limb of which lies along the posterior border of the lower part of the sterno-mastoid, the other extends outwards from this along the clavicle. The external jugular vein is avoided, the omo-hyoid drawn to one side, and the outer border of the scalenus anticus defined. The nerves are seen emerging at the outer border of this muscle. The transverse cervical artery lies in front of the plexus.

Comment.—The operation is seldom given in examinations, it closely resembles that for the exposure of the third part of the subclavian. In life it is sometimes performed to suture a torn nerve trunk, the junction of the fifth and sixth is the one commonly affected. Birth palsy or Erb's paralysis is due to the rupture of the fifth and sixth; here the arm assumes the characteristic position of extension, adduction, and the internal rotation due to the paralysis of the muscles supplied by these nerves.

CHAPTER IV

Amputations and Disarticulations

General considerations—Upper limb—Lower limb.

AMPUTATIONS

General Remarks.—With the growth of conservative surgery and the introduction of antiseptic methods of dealing with disease and wounds, the number of cases which are submitted to amputation has steadily diminished. This will be more readily understood when the student is reminded that the majority of patients with compound fractures of the leg underwent amputation at the site of election or through the thigh, as giving them the best chance of recovery. At present the chief indications for amputation are (1) very bad smashes where the vessels are severed, the bone comminuted, and the soft parts crushed, (2) malignant disease, (3) tubercular disease, (4) gangrene, (5) frost-bite, (6) projectile wounds.

A Good Stump.—A good stump should be firm and rounded, not conical or tender. The skin should be movable over the end of the bone and not adherent to it; its nutrition should be good. The scar should be narrow, firm and situated so as to be free from pressure. The stump should not be tender when pressed upon. All the tissues in the stump waste to a certain extent, the ends of the bones become rounded off, the arteries diminish in size to the requirements of the part, the muscles which are no longer used have their fibres largely replaced with fibrous tissue, the subcutaneous tissue at the end of the stump forms a fibrous cap which acts as a buffer to the end of the bone. The nerve ends become enlarged and rounded chiefly from an overgrowth of fibrous tissue. If these false neuromata are subjected to pressure, pain will result. For this reason the nerve trunks are cut short; the nerve should never be left in the flap on which pressure is subsequently borne.

A Bad Stump.—A stump which has not the qualities enumerated above, must be considered a bad one. The special features of a bad stump are, the skin is drawn tightly over the end, is adherent to the bone, is badly nourished and liable to ulceration. The scar, terminal or situated so as to be irritated by pressure, bears evidences of healing by second intention, keloid formation, or chronic inflammation. Excessive tenderness on the part of the stump means irritation of the ends of the nerves or chronic inflammation of the periosteum of the bone. Of all causes which help to form bad stumps the commonest is suppuration occurring in the wound binding and matting the tissues together.

FIG. 27.—CONICAL STUMP AFTER AMPUTATION THROUGH THE UPPER ARM DURING CHILDHOOD; GROWTH AT THE UPPER EPIPHYSIS.

(*From a cast in St. Mary's Hospital Museum.*)

Besides all these characteristics of a bad stump there is the stump which is bad owing to its shape—the "conical stump." This is a stump in which the end of the bone is badly covered with tissue and projects under the skin.

The causes of a "conical stump" are:

1. The flaps being cut too short.

2. Too low a division of bone, the soft parts not having been retracted sufficiently before the saw was applied.

3. Muscle retraction.—The muscles retract very unequally, those which retract most are the long muscles with little fibrous tissue which are only attached by their ends, the belly of the muscle being free from the bone, such as the biceps, hamstrings, and superficial muscles of the calf. For this reason, conical stumps are common in amputations through the situations of these muscles. The muscles which are attached to the bones for a large part of their course contract much less. Examples of such muscles are the brachialis anticus, the vasti of the thigh,

and the tibialis anticus. Muscles contract much less in wounds which heal quickly than in those in which suppuration occurs.

4. Growth of bone.—In young bones where the epiphyseal line is intact, the growth of the bone may continue and the stump which was well formed at the time of the operation may subsequently become conical. Conical stumps from this cause may require several subsequent operations for the removal of bone before the growth ceases.

5. Suppuration.—It is hardly necessary to include this as a reason if what has already been said is understood. With suppuration, the flaps may slough and the bone protrude, the muscles retract to an unlooked for extent, and the end of the stump be composed of adherent scar tissue.

Methods of Amputating.—With the introduction of anæsthetics the old rapid methods of removing a limb have gradually fallen into disuse. The surgeon is now able to plan his operation deliberately and carry it out with attention to the minutest details. At the same time, freedom from sepsis enables him to estimate accurately what the ultimate shape of the stump will be and to fashion this to suit the function to which it will be put.

1. The Circular Method.—This method is the oldest and is performed in the following manner. The skin incision is made to encircle the limb by the surgeon passing the knife and his right forearm under and then over and so round the limb to be amputated. The knife held vertically with the point downwards is placed with its heel against the skin ; it is now drawn round the limb, the incision being made with the whole length of the blade, the assistant rotating the limb so as to make the integuments meet the knife. The incision only passes through the skin and fascia. The skin is retracted, freed, and turned back evenly all round like a cuff. A second circular incision then divides the muscles, which are then well retracted. A third circular incision divides the remains of the muscles and the periosteum. With a rugine, the periosteum is pushed back a little way and the bone is sawn through. By this method the end of the bone lies at the bottom of a terraced wound, the periosteum falls over the end, the muscles and the skin cover all in without tension.

Modifications of the Circular Method.—Owing to the difficulty in retracting the skin when the limb tapers rapidly, or where there are strong intermuscular septa binding it down, or where inflammation has thickened it and caused adhesions to form, the following method, known as Syme's modification, is often

used. Two small semilunar flaps are made on opposite sides of the limb; these are reflected and then the skin at their base is turned back in the form of a cuff or simply retracted strongly. Another method is to make an incision down one side from the saw level to the circular cut. If two incisions are made, one

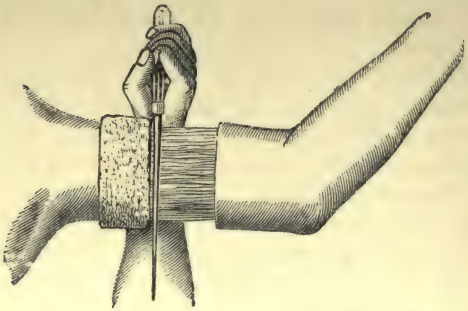


FIG. 28.—CIRCULAR AMPUTATION FOR THE ARM, SHOWING FLAP OF SKIN TURNED BACK, AND KNIFE APPLIED FOR DIVISION OF THE MUSCLES.
(*Rose and Carless.*)

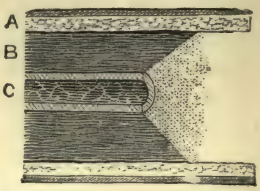


FIG. 29.—SECTION OF PARTS AFTER CIRCULAR AMPUTATION.
A, Skin and subcutaneous fat. B, Muscles. C, Bone.
(*Rose and Carless.*)

on each side, then two rectangular flaps of equal length are marked out. These modifications of the circular method may be applied anywhere where the circular method is described.

2. The Oval or Elliptical Method.—This method is really a circular incision placed very obliquely. It should lie totally below the level of the saw cut, the amount of obliquity of the incision and its distance below the saw cut will increase with the size of the limb. The skin is well retracted and may in part be turned back; the muscles are then cut through with circular sweeps or by transfixion. After division of the bone the skin is folded over the end of the bone, the lower end of the oval being sutured to the upper end. The scar is not terminal.

3. The Racket Method.—This is a circular or oval incision with a straight incision passing up from it. The skin is reflected and retracted and the muscles divided obliquely down to the bone. Examples of this method are given in amputations of the fingers, metacarpals, and the hip. The scar which results is linear, partly on the side and partly at the end of the stump.

4. The Flap Method.—The flaps, usually two in number, are either composed of skin alone or skin and muscle, the skin being cut longer than the muscle. Flaps have the following advantages over the circular method.

(1) They are applicable to any part.

(2) By lengthening one flap, loss of tissue on the opposite side of the limb can be compensated for.

(3) The flaps can be so cut that the scar is made lateral; only when the flaps are equal is the scar terminal.

(4) The scar is less likely to adhere to the ends of the bone.

(5) There is less likelihood of a conical stump resulting.

(6) Skin used to pressure may sometimes be obtained to cover the end of the stump.

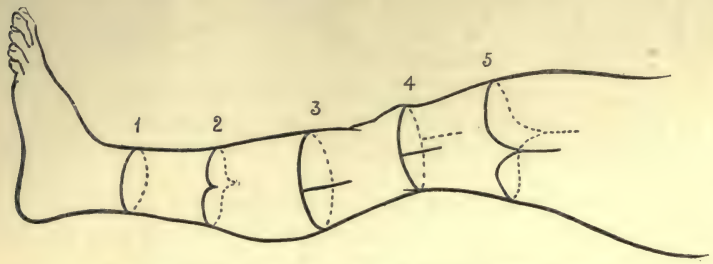


FIG. 30.—EVOLUTION OF THE FLAP AMPUTATION.

1, Circular amputation. 2, Syme's modification. 3, A cut upwards on one side which forms the transverse racket, the corners of which are usually rounded. 4, A cut upwards on each side. 5, The corners of the last rounded, making two flaps of equal length.

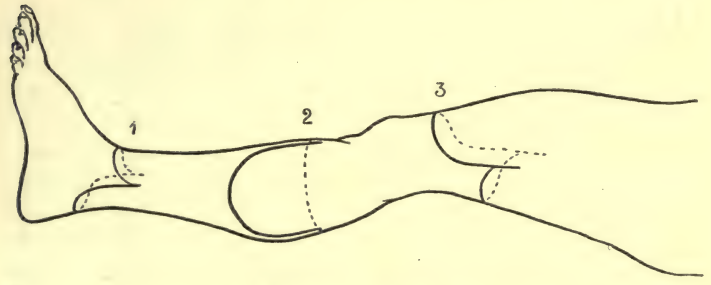


FIG. 31.—EXAMPLES OF UNEQUAL FLAPS, ARRANGED TO SUIT THE ANATOMICAL CONDITIONS OF THE PART.

1, Long posterior and short anterior flap. 2, Long external and very short internal flap. 3, Long anterior and short posterior flap.

The disadvantage of the flap method is that if the flaps are made too long or dissected up too thin, they are liable to slough from deficient blood supply.

Many varieties of flaps have been planned; some of the commoner are here mentioned.

(1) *Double Flaps.*—These may be equal or unequal, lateral or antero-posterior. Many examples of these flaps will be found in the operations given.

(2) *Single Flaps.*—These may be taken from any surface of the limb, anterior, as in Carden's amputation through the condyles of the femur; posterior, as in Syme's, Lisfranc's, or

FIG. 32.—THE OBLIQUE OR OVAL INCISION AND ITS MODIFICATIONS.

1, The oval incision. 2, A cut upwards from the upper end, marking the oblique racket. 3, With the corners rounded off and the highest limit behind. 4, With the corners rounded off and the highest limit in front.

Chopart's amputations on the foot; lateral, as in Faraboeuf's amputation at the seat of election, or the deltoid flap for disarticulating at the shoulder joint.

(3) *Rectangular Flaps.*—As in Teale's method of amputating through the leg.

(4) *Irregular Flaps.*—As in some of the operations on the foot, *e.g.* the subastragaloid amputation.

Shape, Size, and Composition of Flaps.—As a rule, the beginner makes the mistake of cutting the flaps too pointed, "tailing them off" as it is termed. They should be made broadly U-shaped, and are perhaps better described as being rectangular with the angles rounded off. The disadvantage of having angles is that the nutrition of the extreme angle is bad, and with sloughing the wound is liable to be infected. The knife should be made to travel vertically along the sides and curved gently across the limb. One flap should be made longer than the other so as to avoid a terminal scar. If the skin did not contract it is obvious that flaps, which together were equal to the diameter of the limb, would be amply long enough to cover the end of the stump. But owing to the retraction of the skin, one third more has to be added to this length. Flaps which are together equal to a diameter and a half of the limb are safe and can be sutured without tension. A preliminary measurement of the flaps can be made by the surgeon spanning the limb with his left hand at the level of the proposed saw cut, the finger and thumb being on opposite sides. The thumb being kept in place the hand is made to pivot upon the thumb; the forefinger will then mark out a point which is distant from the

thumb the diameter of the limb. The forefinger should then be replaced on the opposite side of the limb and kept in place till the flaps have been cut.

The knife should always be held at right angles to the skin, which must be cleanly divided. The vessels which nourish the skin run in the superficial fatty tissue, which must be dissected up as thick as possible for 2 to 2½ inches. If the flap is longer than this, the deep fascia should be included beyond this point. To make sure of securing the deep fascia, some muscle fibres should show on the surface of the base of the flap. Long flaps which contain only the skin and fascia are very liable to slough, and the surgeon is then in a worse position than if he had made the mistake of cutting the flaps too short.

Some flaps, such as those cut by transfixion or by Teale's method, etc., contain a large proportion of muscle, and are therefore thought to produce a better covering for the bone. This, however, is not due to the muscle which is contained in the flap, as this rapidly wastes, but to the connective tissue which replaces the muscle. For this reason nearly all methods attempt to bury the end of the bone deeply in muscle tissue so that a connective tissue buffer will form later over the end of the bone.

This method of cutting flaps is called the "method by dissection" in contradistinction to the "method by transfixion." In the transfixion method, the muscles and skin are cut together. In the old days, this was a rapid and very favourite way of fashioning the flaps. It is, however, difficult to cut flaps with accuracy in this manner, or to make sure that the skin is cut longer than the muscles. The need of extreme rapidity having vanished with the appearance of anæsthetics, this method is seldom employed; examples are described in amputations through the forearm and hip.

AMPUTATIONS—UPPER LIMB

Amputations of Fingers and Thumbs

Anatomy.—1. *Position of the joints.*—On the front of the fingers the three creases form useful guides to the position of the joints. The lowest crease, usually narrow, is situated immediately above the level of the second interphalangeal joint; the middle crease, broad and double, lies opposite the first interphalangeal joint; the highest and least important crease is about three quarters of an inch below the level of the metacarpophalangeal joint. A knife entered from the front at the highest part of the middle crease and one entered at the lowest part

of the lowest crease will enter respectively the first and second interphalangeal joints.

On the dorsum of the hand, the prominence or knuckle of the joint is always formed by the lower end of the proximal bone, therefore the line of the joint is a little below this. In addition it should be remembered that in nearly every case the exact line of the joint may be made out at the side of the finger if the thumb nail pressed against the lateral ligament.

2. *The Theca or Tendon Sheaths* commence opposite the base of the terminal phalanx and extend down to the metacarpo-phalangeal joints. They are attached to the sides of the phalanges and form a strong inelastic tunnel, better marked over the first than the second phalanx, weak and lax opposite the interphalangeal joints. Owing to their rigidity, they do not collapse when cut across.

3. *The Synovial Sheaths.*—The common synovial sheath of the flexor tendons extends from about one and a half inches above the anterior annular ligament of the wrist to the middle of the metacarpal bones or the level of the superficial palmar arch. From the common sheath a prolongation to the little finger extends along the tendons to their insertion, reaching the base of the terminal phalanx and lining the theca. The synovial sheaths which enclose the tendons of the second, third, and fourth digits and line the theca of these digits, extend upwards into the palm and end opposite the necks of the metacarpals, a distance of about half an inch separating them from the common synovial sheath. The synovial sheath surrounding the tendon of the flexor longus pollicis extends from the base of the terminal phalanx of the thumb to about an inch above the anterior annular ligament, in many cases it communicates with the common synovial sheath of the flexors. These synovial sheaths form a ready channel along which sepsis may travel from the fingers to the deeper parts of the palm, and in the case of the first and fifth digits to the forearm. Care must therefore be taken to perform even the slightest operation on the fingers in an aseptic manner ; especially is this needful when the theca is cut into.

4. *Ossifications.*—See Excision of Metacarpals, p. 198.

5. *Ligaments.*—All the joints possess lateral and palmar ligaments ; the latter consists of a fibro-cartilaginous plate which, in the case of the metacarpo-phalangeal joint of the thumb, is strengthened by the presence of two sesamoid bones. The dorsal expansions of the extensor tendons form the chief support behind.

6. *The Vessels and Nerves.*—The digital vessels and nerves run much nearer the palmar than the dorsal surface of the fingers on either side. In the palm of the hand, the arteries are in front of the nerves, but in the fingers this position is reversed.

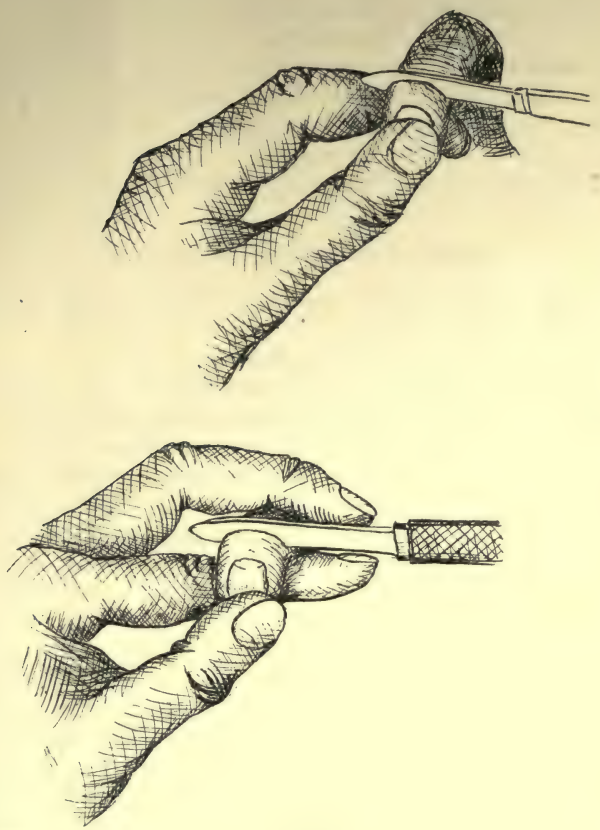


FIG. 33.—AMPUTATION OF THE TERMINAL PHALANX. TWO METHODS OF HOLDING THE FINGER.

Instruments.—A narrow-bladed scalpel with a blade an inch and a half long, artery and dissecting forceps, scissors, fine saw, needles and suture material.

Position.—This will vary according to the method adopted. Generally the surgeon holds the injured finger in his left hand; the assistant steadies the wrist and holds the sound fingers out of the way.

Methods.—The methods which may be adopted in nearly all the amputations and disarticulations of the digits are as follows:—

1. Long palmar flap.
2. Palmar and dorsal flaps: A, equal; B, unequal.
3. One long lateral flap.
4. Two lateral flaps: A, equal; B, unequal.

Of these methods the long palmar flap or long palmar and short dorsal flap, are the most used, as the scar is out of the way on the dorsum and the skin of the palm is thick and used to pressure. Equal flaps, whether lateral or antero-posterior, leave a scar which is exposed to pressure. The fact that the digital artery is always in the palmar flap should be remembered.

Removal of the Terminal Phalanx

Methods.—The methods employed in this operation are:—

1. Long palmar flap.
2. Long palmar and short dorsal flaps.

1. *The long Palmar Flaps.*—The phalanx to be removed is grasped by the left hand of the surgeon and well flexed; or the surgeon may place his left forefinger below and in front of the joint and flex the phalanx over it with his thumb, his middle finger being placed on the dorsum of the middle phalanx to steady it. The scalpel is then drawn from heel to tip across the dorsum of the joint, which it should enter at once. The knife should pass sufficiently deep to divide the lateral ligaments.

The phalanx is strongly flexed and pulled upon, the blade insinuated in front of its base, and with a sawing motion the anterior ligament, the insertion of the flexor profundus digitorum, and the pulp are separated from the front of the phalanx. The end of the flap should be square enough to fit the dorsal incision without tension. Any bleeding vessels are pinched with forceps, a ligature being unnecessary. The flap is then turned up over the head of the phalanx and stitched in position. The tendon sheath is not opened.

2. *The long Palmar and short Dorsal Flap.*—In this case the knife is drawn across the back of the phalanx below the line of the joint and a short flap dissected up before the joint is opened. The rest of the operation is completed as before, a shorter palmar flap being now needed.

If no narrow-bladed knife is to hand the proceedings may be modified by dissecting up the palmar flap first and then opening into the joint from the dorsum and so completing the operation.

Amputation through the Second Phalanx

In injuries to the fingers it is desirable to leave a portion of the middle phalanx instead of removing the whole bone. If possible the amputation should be made through the middle of the bone so as to leave the proximal portion with the attachment of the flexor sublimis digitorum on each side. If this is not done the first phalanx is left stiff and useless, unless steps be taken to fasten the tendons to the periosteum at the end of the bone or to stitch the flexor and extensor tendons together over the head.

The **methods** employed in this operation are :—

1. Long palmar flap.
2. Long palmar and short dorsal flaps.
3. Equal palmar and dorsal flaps.
4. One long lateral flap.
5. Two lateral flaps : A, equal ; B, unequal.

Of these the first two are those mostly employed.

1. *By a long Palmar Flap.*—The finger is held as in the last operation, a piece of narrow bandage being wrapped around the terminal portion so as to allow a secure hold. An incision is made by drawing the knife from heel to tip across the dorsum at the level of the proposed section of the bone, so as to divide the soft tissues completely. The narrow-bladed knife is then entered at one extremity of the incision and passed across the front of the phalanx to emerge at the other. With a sawing movement a flap is cut about three-quarters of an inch long, keeping as close to the bone as possible, and then cutting outwards so as to end the flap squarely. The flap is then retracted, the knife passed round the periosteum and the bone divided with a fine saw. The bleeding is arrested, a ligature being applied to the digital artery on each side at the end of the palmar flap, which is then stitched in position.

2. *By a long Palmar and short Dorsal Flaps.*—A short, well rounded dorsal flap is marked out and dissected up from the back of the bone. The knife is then passed across the front of the bone, entering at one side and emerging at the other side of the base of the dorsal flap. A palmar flap about two-thirds of an inch long is cut as before. The remainder of the operation is completed in the same way.

3. *Equal Palmar and Dorsal Flaps.*—The knife is entered on the lateral aspect of the phalanx opposite where it is proposed to divide the bone, and carried down for a distance of half an inch, and then with a gentle curve it passes across the dorsum

and up on the other side of the finger. A similar flap is marked out on the palmar aspect by carrying the knife in a curved manner across the front, joining the two lower ends of the lateral incisions. These two flaps are dissected up, the tendons divided, and the bone cleared. The bone is then sawn through, the bleeding arrested, and the flaps stitched together. The scar which results is necessarily exposed to pressure.

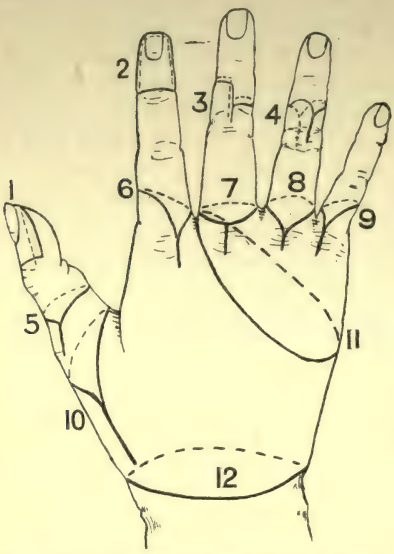


FIG. 34.—AMPUTATIONS ABOUT THE HAND.

Amputation of Terminal Phalanx: 1, Long palmar flap. 2, Short dorsal and long palmar flap.
Amputation of or through the Second Phalanx: 3, Unequal lateral flaps. 4, Equal lateral flaps.
Amputation at Metacarpo-Phalanged Articulation: 5 and 8, Racket method. 6 and 9, Racket method for 2 and 5 digits. 7, Modified circular. 10, Amputation of thumb and metacarpal bone by racket method. 11, Partial amputation through the metacarpals. 12, Amputation at wrist by circular method.

No special description need be given for the dissecting up of similar flaps taken from the lateral aspects of the fingers.

If a saw is not available the bone may be divided with a pair of bone forceps, care being taken that the bevelled side of the forceps is towards the part to be removed. The forceps are inferior to the saw, inasmuch as splintering of the bone is liable to take place.

Amputation through the First Interphalangeal Articulation

Any of the methods enumerated above may be used to amputate at this level, but the method generally employed is by the long palmar and short dorsal flaps.

The long Palmar and short Dorsal Flaps.—The level of the joint having been defined a short dorsal flap a quarter of an inch long is marked out and dissected up. The joint is then entered from the dorsal surface and the palmar flap, about two-thirds of an inch long, is cut by insinuating the edge of the knife in front of the base of the phalanx and cutting parallel with the front of the bone. To do this the phalanx is well flexed and pulled towards the surgeon. The knife is then made to cut outwards

to the palmar surface, and the bone removed. The vessels are caught on either side; they should spout at the free end of the flap. The flexor tendons are stitched to the extensor tendons over the head of the bone, and the flap folded up and stitched in position.

Another way is to stitch the extensor tendons to the periosteum of the back of the bone and the flexor tendons to the edges of the theca. Both methods produce a movable stump.

Amputation at the Metacarpo-Phalangeal Articulation

The **methods** adopted for this operation are:

1. The racket method.
2. The lateral flaps.
3. Modified circular method.
4. Single palmar flap.

The methods commonly adopted are the first two.

1. *By the Racket Method.*—The finger to be removed is firmly grasped in the left hand of the surgeon, the adjacent fingers are held out of the way by the assistant, the hand being pronated throughout the operation. The knife is entered on the dorsum opposite the neck of the metacarpal bone or two-thirds of an inch above the line of the joint, and is carried down in the mesial line of the finger past the base of the phalanx. From here the knife sweeps obliquely down the side of the phalanx to the level of the web of the finger; a second incision, exactly corresponding, is made to the level of the web on the opposite side of the phalanx.

A third incision joins the extremities of the first two across the front of the root of the finger at the level of the web. The incisions should be made down to the bone, the digital arteries, lumbricals, and interossei being severed by the two lateral cuts; the palmar cut should be made with the finger extended so as to put the flexor tendons on the stretch, in order to ensure their clean division. The assistant steadies the finger while the surgeon dissects back the flaps with knife and forceps. The finger is then flexed and the extensor tendon being divided, the joint is opened. The knife is carried against the lateral ligaments on either side, the finger being bent laterally to render tense each in turn, and with a few touches of the knife the disarticulation is completed. The arteries are caught at the edge of the web near the palmar aspect.

In amputating the index or little finger the dorsal part of

the incision should be placed rather on the ulnar side of the former and on the radial side of the latter, so as to ensure that the scar comes well on to the back of the hand away from possible pressure.

2. *Lateral Flaps.*—The surgeon holding the finger, with the hand in the same position as in the last operation, marks out two lateral flaps, one on each side, with their bases corresponding to the line of the joint and their free margins at the level of the web of the fingers. To do this the palm must be cut into. The incisions, which are not made down to the bone, are completed as follows. The flap to the surgeon's right hand is dissected up down to the bone, and the lateral ligament of the joint exposed; this ligament is cut by pressing the knife against it with the blade held vertically with the point up, the finger at the same time being bent to the surgeon's left to render the ligament tense. The knife, held in the same position, is passed across the joint severing the flexor tendons, the anterior and the opposite lateral ligaments. The knife is then made to cut the left flap from within outwards, and the finger removed.

3. *By a Modified Circular Incision.*—This is also a modification of the racket incision already described. The surgeon holding the hand completely supinated cuts across the front of the root of the finger, opposite the web, passing down to the bone so as to divide the tendons, and prolongs the ends of the incision round to the back of the finger. The hand is now pronated and a vertical cut made in the middle line of the finger from opposite the neck of the metacarpal to join the circular cut. The flaps are dissected up and the disarticulation completed as in the racket method.

4. *A long Palmar Flap.*—This is only made use of when the destruction of the tissues renders one of the other methods unavailable.

In patients where appearance is of more importance than the subsequent firmness of the grip of the hand; the head of the metacarpal bone may be removed, but where the usefulness of the hand afterwards is of prime importance this should never be done, as the grip is thereby seriously impaired. When it is considered desirable to remove the head of the metacarpal this should be done with a narrow saw in preference to the bone forceps, as the latter are liable to splinter the bone. The line of the section should be made from behind forwards and downwards. In the cases of the fore and little finger the section should be made slightly downwards and inwards, towards the middle line of the hand.

Amputation of a Finger together with its Metacarpal Bone

This is usually done by the racket method. The line of the carpo-metacarpal joint being made out, an incision commencing at this point is carried down the back of the metacarpal to just beyond the head, where it divides and passes round the base of the finger at the level of the web.

The incision, which only passes through the skin, is deepened

FIG. 35.—AMPUTATION OF THE THIRD AND FIFTH DIGITS, WITH THEIR METACARPAL BONES. AMPUTATION AT THE WRIST BY DUBRUEIL'S METHOD.

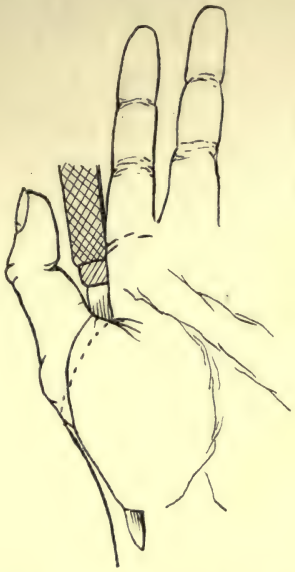


FIG. 36.—AMPUTATION OF THE THUMB AND METACARPAL BONE.

along the back, and the extensor tendon divided near the base of the bone. With the edge of the knife kept close to the bone the interossei are cleared from the side and the interosseous ligament on either side of the base divided, care being taken not to run the point of the knife deeply into the tissues of the palm, as serious hæmorrhage might ensue. The head of the bone is next cleared by deepening the incision round the web, and with the finger strongly extended dividing the flexor tendons. By forcibly extending the finger the palmar aspect of the bone can now be cleared, the tissues of the palm being interfered with as little as possible. The base of the bone can then be dislocated

backwards and ligaments, and such tendons as the flexor carpi radialis or the extensores carpi radiales longior and brevior, divided.

All bleeding having been arrested, the sides of the wound are brought together with sutures.

Amputation of the Thumb at the Carpo-Metacarpal Articulation

Anatomy.—The line of the carpo-metacarpal joint of the thumb is a full inch below the tip of the styloid process of the radius, and can be felt by running the thumb nail up the outer side of the shaft of the first metacarpal. The radial artery in its second part lies at the bottom of the hollow between the extensor longus and the extensor brevis pollicis tendons; the incision therefore should not pass far up into this hollow for fear of wounding the vessel. The artery passes forward into the palm at the proximal end of the first interosseous space.

This operation may be performed by one of two methods—

1. The racket method. (Fig. 34, 10.)
2. The palmar flap. (Fig. 36.)

1. *The Racket Method.*—The line of the joint being made out, an incision, commencing at this point between the tendons of the extensor longus and the extensor brevis pollicis, passes down on the back of the bone to the head, where it divides to pass round the root of the thumb at the level of the web. The sides of the incision are dissected up, keeping very close to the bone, especially on the ulnar side. The head is cleared by deepening the incision in front, and by hyper-extending the thumb the palmar surface comes into view and is dissected out. The dislocation of the base is affected by twisting the thumb from side to side and dividing the structures as they are put on the stretch, the tendon of the extensor ossis metacarpi pollicis being one of the last structures divided.

2. *By the Palmar Flap.*—The hand is held by an assistant with the palm uppermost while the surgeon abducts the thumb. The flap is cut by transfixion. The point of the knife is entered at the centre of the web and passing beneath the muscles of the thenar eminence, emerges opposite the base of the metacarpal. By keeping close to the front of the bone and sawing outwards, a thick flap, consisting of all the muscles of the thenar eminence, is raised up. The two ends of this incision are now joined round the radial border of the thumb by a slightly curved incision. The metacarpal bone is then dissected out, the edge of the knife being kept close to the bone throughout. The joint is opened

from the front and the disarticulation completed as before. All bleeding is arrested and the palmar flap folded over and stitched to the margin of the posterior cut.

Comment.—Of the two methods, the latter is slightly the more rapid, but the former is the safer and neater of the two.

Amputation at the Wrist Joint

Anatomy.—The two most important landmarks are the styloid processes of the radius and ulna, the former lies half an inch below the level of, and on a more anterior plane than, the latter.

The deepest crease on the front of the wrist corresponds to the upper edge of the anterior annular ligament, and is about three-quarters of an inch below the level of the centre of the wrist joint, and about half an inch above the line of the carpo-metacarpal joints. The three prominent tendons which can be made to stand out on the front of the wrist are, from without inwards, the tendons of the flexor carpi radialis, the palmaris longus, and the tendons of the superficial division of the flexor sublimis digitorum, which belong to the middle and ring fingers. Behind the tendon of the palmaris longus and slightly to its outer side is placed the median nerve. On the back of the wrist is the tubercle of the radius, from the inner side of which the tendon of the extensor longus pollicis begins to be promiment.

The synovial sheaths are two in number on the front of the wrist; their positions and extent have already been described with the anatomy of the fingers. On the back of the wrist are six separate synovial sheaths. From without inwards they contain: (1) the extensor ossis metacarpi pollicis and the extensor brevis pollicis; (2) the extensor carpi radialis longior and brevior; (3) the extensor longus pollicis; (4) the extensor communis digitorum and the extensor indicis; (5) the extensor minimi digiti; (6) the extensor carpi ulnaris.

Vessels.—The course of the radial artery may be marked out by drawing a line from half an inch internal to the styloid process of the radius to the sulcus distinctly felt between the bases of the first and second metacarpals. The vessel lies on the external lateral ligament of the wrist joint below the styloid process, and then under cover of the extensor tendons of the thumb.

The ulnar artery lies to the outer side of the pisiform but to the inner side of the hook of the unciform. Immediately below the pisiform the vessel divides into its superficial and deep divisions. The ulnar nerve lies to the ulnar side of the artery

and divides at the same spot. The superficial carpal arch corresponds to the middle third of a line drawn across the palm at the level of the web of the thumb ; the deep palmar arch lies about half an inch on the proximal side of this line.

The wrist joint has a separate synovial membrane. Occasionally, the triangular fibro-cartilage of the wrist and inferior radio-ulnar joints is perforated, and in that case the synovial membranes of the two joints are continuous. Of the ligaments about the joint the two lateral ones are very strong, the anterior and posterior are weak, the former being stronger than the latter.

Indications.—Amputation at the wrist is rarely performed, but may be called for in cases of severe injury to the hand and metacarpus, gangrene, or burns ; sometimes after excision of the wrist for tubercular disease has failed, although here the presence of sinuses usually drives the surgeon to amputate at a higher level. In all cases where it is necessary to sacrifice the hand, the amputation should, if possible, be through the wrist joint, as this leaves the patient with the power of supination and pronation which are lost in amputations higher up.

Methods.—Many methods are employed in carrying out this operation ; these are described in their order of merit.

1. Long palmar flap.
2. Elliptical incision.
3. Circular incision.
4. Method of Dubrueil.

1. By a long Palmar Flap

In all methods it is best to control the brachial artery with a tourniquet on the upper arm. The limb is extended and abducted from the side of the body with the palm uppermost, the wrist extended and the thumb abducted. The bony points being defined, a U-shaped flap is marked out, commencing at the tip of one styloid process and ending at the tip of the other, passing straight down on the thenar and hypo-thenar eminences and curving across the palm at the level of the superficial palmar arch. This flap is dissected up from off the flexor tendons and should contain some of the muscular fibres from the thenar and hypo-thenar eminences so as to include the superficialis volæ and the ulnar arteries. The flap is reflected as high as the wrist joint. The hand is next pronated and the wrist flexed and an incision, lightly curved downwards, made from the tip of one styloid process across the dorsum to the other. The joint, strongly flexed, is opened from the dorsum and the extensor tendons severed. The palmar flap is retracted and the assistant

pulls on the hand while, with clean cuts of the knife, the surgeon divides all the flexor tendons at the level of the wrist and removes the hand. Care must be taken not to open into the inferior radio ulnar joint, as thereby pronation and supination might be endangered. The tips of the styloid processes may be removed with saw or forceps. The vessels which need ligaturing are the radial, superficial and deep divisions of the ulnar, carpal branches of both, superficialis volæ, and the anterior and posterior interosseous arteries. The palmar flap is then laid over the ends of the bones and sutured in position.

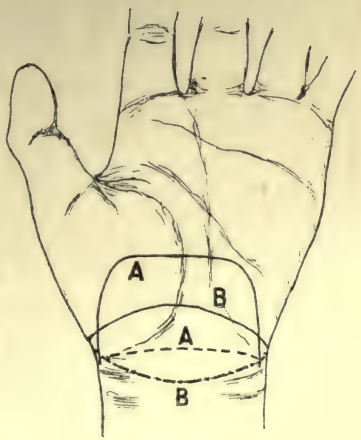


FIG. 37.—AMPUTATION THROUGH THE WRIST JOINT.
A, By a long palmar flap. B, By the elliptical method.

2. The Elliptical Method

The elliptical or oval incision should lie as follows. The highest part is on the dorsum, half an inch below the level of the wrist joint. The lowest point is in the palm, two and a half inches below the level of the wrist. On the outer side, the incision crosses the carpo-metacarpal joint of the thumb; on the inner side it passes between the pisiform and the base of the fifth metacarpal bone.

With the hand fully supinated, the palmar half of the ellipse is first formed; the hand is then pronated and the posterior part marked while the assistant pulls up the integuments. The incision divides the skin and subcutaneous tissues only. The dorsal part of the incision is deepened and reflected to the level of the joint.

The wrist is fully flexed and the surgeon divides in order the lateral ligament on one side, the extensor tendons, the posterior ligaments of the wrist joint, and the lateral ligament on the other side. The joint is thus freely opened and the knife insinuated in front of the carpus, dividing the anterior ligament of the wrist and then passing between the bones and the flexor tendons. The arm is then placed midway between supination and pronation and the surgeon, holding the knife vertically, saws his way obliquely through the flexor tendons, making the knife emerge at the previously made skin incision.

The resulting scar is placed on the back of the stump.

The student will at once see that the operation can be carried out by the same steps as described in the long palmar flap method. The disadvantage of cutting tendinous flaps from within outwards is that the tendons are apt to be pulled down and ragged instead of being divided cleanly; this disadvantage may be avoided by dividing the tendons with a strong pair of scissors.

3. The Circular Method

The hand fully pronated is steadied by an assistant while the surgeon draws up the skin of the forearm. The first circular incision commences on the dorsum and passes half an inch below the level of the carpo-metacarpal joints of the first and fifth digits, *i.e.* about two inches below the styloid processes. This incision only divides the skin and sub-cutaneous tissues, which are strongly retracted and freed to the level of the joint.

The second circular incision is made immediately above the level of the pisiform bone, dividing the extensor and flexor tendons, the vessels and nerves. The ligaments proper to the joint are divided and the hand removed, the styloid processes clipped off, and the rest of the operation completed as before.

4. The Method of Dubrueil (Fig. 35)

This is nothing more than an amputation by a lateral flap, which in this case happens to be taken from the thumb. The hand being pronated, the incision commences at a point just below the level of the wrist joint and at the junction of the outer with its middle third. The incision passes down on the back of the hand to the thumb, which it crosses transversely at its middle. " The incision now follows the inner part of the thenar eminence, and terminates at a point diametrically opposite to the point at which it commenced." The flap, which should contain as much of the muscles of the thenar eminence as possible, is dissected up. The two ends of the base of the flap are joined by an incision which passes transversely round the inner side of the wrist at that level. The joint is opened and the disarticulation completed.

Should sufficient tissue be available, this method may be employed to take the flap from the hypo-thenar eminence, the incisions being reversed.

Comment.—The tough skin of the palm which covers the ends of the stumps when the amputation is performed by the long palmar flap or elliptical methods is admirably adapted to withstand pressure, but is rather stiff and unyielding. The

stitches for this reason should take a good hold of the tissues. Some surgeons prefer to leave the styloid processes; they are of no value and give to the stump an ungainly appearance.

Care should be exercised to prevent opening into the inferior radio-ulnar articulation or the movements of pronation and supination may be lost. Dubrueil's operation is useful, but where so much healthy tissue from the thumb is available it may possibly be worth while to save a portion of that digit.

After-treatment.—A drainage tube should be inserted at one angle of the wound to prevent the accumulation of discharges, the presence of the open tendon sheaths being remembered.

The limb should be placed on a right-angled splint attached to the inner side of the upper and forearm, so as to control the elbow and radio-ulnar joints and support the palmar flap.

Amputation through the Forearm

Anatomy.—On cross-section the forearm is oval, but differs in composition very much at different levels, being chiefly muscular in the upper and tendinous in the lower part. The methods of amputating therefore vary according as they are applied to the upper and lower portions.

At all levels the bones are nearer the posterior than the anterior surface. This is better marked in the upper fleshy than in the lower tendinous portion of the forearm.

The position of the muscles which produce pronation and supination must be borne in mind with regard to the future movements of the arm. The pronator muscles are the pronator radii teres and the pronator quadratus. The supinators are the biceps and the supinator brevis; the supinator longus being chiefly a flexor of the elbow. If the bones are divided above the insertion of the pronator radii teres there will be no pronators left to antagonize the action of the supinators. Amputations should therefore take place, if possible, below this level, *i.e.* through the lower half of the forearm.

The vessels are chiefly on the front of the bones. The radial artery is accompanied on the radial side by its nerve in the middle third of the forearm only; above this the nerve lies to the outer side, while below the nerve passes round to the back of the limb. The ulnar artery is accompanied in its lower two-thirds by its nerve, which lies on the ulnar side of the vessel. The anterior interosseous artery lies on the interosseous membrane. The posterior interosseous artery lies between the superficial and deep muscles on the back of the forearm. The brachial artery divides opposite the neck of the radius, while the ulnar

gives off the common interosseous trunk, one and a half inches below the level of the elbow joint.

Methods.—The following are here described.

1. Skin flaps with circular division of the muscles.
2. Transfixion flaps.
3. Circular method.
4. Teale's method.

Instruments.—An amputating knife with a blade four or five inches long, a scalpel, saw, artery and dissecting forceps, scissors, needles, ligature and suture material. For retracting the soft parts a broad calico bandage may be used. It is sterilized and torn into three slips, one of which passes on each side of the

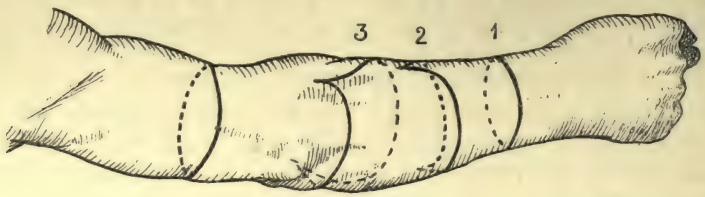


FIG. 38.—AMPUTATION THROUGH THE FOREARM AND ELBOW.
1, The forearm by the circular method. 2, The forearm by short anterior and posterior flaps. 3, The elbow by a large anterior and short posterior flap.

bones, the middle one passing between them. Traction on the ends will now effectually prevent the saw damaging the soft tissues.

Position.—The patient lies on the back with the limb abducted, the elbow extended, and the forearm fully pronated (unless otherwise mentioned for special methods). The surgeon stands on the right of the limb—outside the right and inside the left arm. This rule holds good for all amputations. One assistant steadies the hand, standing on the right of the surgeon, another stands opposite, facing him.

1. Skin Flaps with Circular Division of the Muscles

1. *The Flaps.*—The surgeon places his forefinger and thumb on the borders of the forearm opposite the place at which he intends to divide the bones. The incision commences on the far side of the limb below the forefinger, passes down the limb for about three inches, curves across the dorsum of the limb, and finally ascends on the near side to just below the thumb. The limb is now fully supinated, and a similar flap, two inches long, cut on the flexor aspect. Both these incisions pass through the integuments only.

The two flaps are dissected up, containing the skin and fascia.

2. *Division of Muscles.*—The flaps being well retracted, the muscles are all divided down to the bone by circular sweeps of the knife.

3. *Division of the Bones.*—The muscles are well retracted and the interosseous membrane and periosteum of the bones severed. The bandage retractor is applied to protect the soft parts while the saw is used in the following way. The limb is fully supinated, the heel of the saw is placed on the nearer bone and drawn lightly from heel to toe three times to make a groove. As soon as the instrument has made a track the blade is made to engage the other bone. The two bones are then sawn together with light strokes of the saw, the whole length of the blade being used. The strokes should become lighter and shorter as the division approaches completion. The assistant in charge of the hand must hold the limb steady, exercising slight traction on it, and taking care that he neither locks the saw by raising the hand nor splinters the last portion of bone by depressing it.

The vessels are now secured; the radial lies under cover of the supinator longus on the bone; the ulnar under the flexor carpi ulnaris close to the bone; the anterior and posterior interosseous near the interosseous membrane. The nerves, median, radial, and ulnar, are pulled down and cut short. Any tendons which may need it are trimmed, and the flaps sewn in position.

If the condition of the soft parts necessitate it, the flaps may be taken from the lateral aspects of the limb, the surgeon placing his finger and thumb on the flexor and extensor surfaces of the arm and cutting his flaps as before.

2. Transfixion Flaps

1. *The Flaps.*—The hand being fully pronated the surgeon lifts up the tissues from the back of the forearm at the level of the division of the bones. A narrow-bladed knife four to five inches long is sent across immediately behind the bones, care being taken that the point does not pass between them. With a sawing movement the knife is made to pass downwards and forwards, shaping a broad flap three to four inches long according to the condition of the skin on the opposite side of the limb. The skin should be cut a little longer than the muscles by continuing the sawing motion after the latter are cut through. The arm is then supinated and the knife passed across the front of the bones, care being taken to see that the point emerges at the incision already made on the opposite side, this flap should be two or three inches long.

2. *Division of the Bones.*—The flaps are then retracted and the periosteum divided with sweeps of the knife, which is passed also between the bones. The bones are divided with the saw, the soft parts being protected with the three-tail retractor. The vessels are caught and ligatured. The nerves should be sought and cut square.

3. The Circular Method

1. *Skin incision.*—The surgeon pulls the skin well up with his left hand while with the right he passes the knife round the forearm until it is held vertically with the edge against the border of the limb nearest him. The incision is begun with the heel of the knife and should finish with the point, the whole length of the blade having been used. The assistant rotates the limb to meet the edge of the knife. The incision only divides the skin and subcutaneous tissues. The skin is dissected up and turned back like a cuff for about two and a half inches.

2. *Division of Muscles.*—A second circular sweep of the knife is made dividing the muscles and tendons down to the bones.

3. *Division of the Bones.*—The periosteum of the bones is severed and the interosseous membrane divided; the retractors applied and the amputation finished as before.

4. Teale's Method

A full description of a Teale's amputation is given under amputations of the leg. The forearm, however, lends itself to a very rapid method of cutting the rectangular flaps. The posterior flap equals in length and width half the circumference of the limb at the saw-line; it is rectangular and the same width all the way down. The anterior flap is similar but only a quarter the length of the posterior. Both contain all the tissues off the bones; they are cut as follows:—The hand is fully supinated, the saw-line marked with the forefinger and thumb on the borders of the limb. The limb is transfixed at the saw line, the knife passing in front of the two bones. With a sawing movement the knife is carried down close to the bones for a distance equal to half the circumference of the limb. The knife is not brought out at the end of the long flap, but is slid three-quarters of the way back to the starting point, the edge is turned away from the bones and made to cut directly outwards, thus the short anterior flap is fashioned. The limb is next fully pronated and the two lower ends of the transfixion incision are joined across the back of the limb by a cut which

passes right down to the bone, marking off the lower end of the posterior flap.

It only remains to raise the posterior flap off the bones and interosseous membrane and apply the saw.

The long flap may be obtained from the front of the limb in the same way if the hand is pronated and the knife thrust through behind the bones.

Comment.—Of the methods described the first is probably the best, being easy, rapid, and procuring a good covering for the ends of the bones; the scar, if the flaps are of unequal length, never falling at the ends of the stump. The transfixion method, often employed, is apt to be ragged in the lower third of the forearm where the muscular bellies have given place to tendons, while in the upper it is difficult to cut the skin longer than the muscles. The rapidity of the transfixion method is its great advantage. The circular method is inadmissible in the upper two-thirds of the arm on account of the great bulk of muscles and the difficulty of retracting the skin, but in the lower third it is eminently suitable as the muscles have given place to tendons and the skin is easily retracted. Although the tendons produce rather a poor covering for the ends of the bones, this is no drawback, as the pressure of an artificial hand is all taken laterally and not at the end of the stump. Teale's method is wasteful here as elsewhere, but produces an excellent covering for the stump. It is useful if there has been a large destruction of tissue on one side of the limb.

Amputation at the Elbow Joint

Anatomy.—The bony eminences about the elbow joint are easily felt and afford great help in determining the exact position of the joint even in cases of great œdema. The internal condyle is the most prominent point, the external condyle being more rounded. The internal condyle is situated about an inch above the level of the joint, the external only about three-quarters of an inch above that line. This is due to the fact that the joint line slopes from without downwards and inwards, so that the forearm is set at a carrying angle of about fifteen degrees to the long axis of the humerus. In the groove between the internal condyle and the olecranon process is lodged the ulnar nerve.

Posteriorly below the external condyle is a depression in which the head of the radius can be felt to rotate. In front the tendon of the biceps can be made out. Immediately to the inner side of this is situated the brachial artery, before it dips

into the anticubital fossa to lie in front of the tendon. The brachial artery divides a finger's breadth below the bend of the elbow.

The triceps muscle is inserted into the sides as well as the tip of the olecranon. The brachialis anticus is inserted into the root of the coronoid process. The biceps, after giving off a strong slip to the fascia of the forearm in front of the brachial artery, passes to be attached to the posterior part of the tuberosity of the radius. The lateral ligaments of the joint are strong, the anterior and posterior are weak and lax, the former being the stronger of the two.

The anastomosis about the elbow joint is important only for the purposes of collateral circulation, but the vessels are small and are easily controlled. Few ligatures need be applied after the main vessels are controlled. The position of the ulnar nerve has already been indicated. The median nerve lies immediately to the inner side of the brachial artery. The musculospiral nerve ends opposite the front of the external condyle by bifurcating into the posterior interosseous and the radial nerves.

Before the tenth year the upper end of the olecranon is wholly composed of cartillage.

Methods.—

1. Long anterior and short posterior flaps.
2. Elliptical method.
3. Circular method.
4. Lateral flaps.

Position.—The arm is abducted from the body. The surgeon stands on the right of the limb, *i.e.* outside of the right and inside of the left arm. The assistants should stand one on the right and one facing the surgeon.

1. The long Anterior and short Posterior Flaps.

1. *The Flaps.*—An incision is begun on the far side of the limb (left), one and a half inches below the external condyle, and passing downwards is curved across the front of the limb to ascend to a point one inch below the internal condyle, marking out a flap about three inches in length. The incision is deepened and the skin retracted strongly. The muscles on the front of the limb are picked up with the left hand and are cut by transfixion to the level of the retracted skin. Passing the knife under the limb the two extremities of the base of the anterior flap are joined by a curved incision marking out a posterior flap one and a half inches long from the skin over the

olecranon process. With the edge of the knife turned towards the bone to prevent button-holding, the posterior flap is raised from the ulna.

2. *Disarticulation.*—The flaps are well retracted and the bones cleared in front of the joint. The joint is opened on the outer side first, and the ligaments divided as the assistant pulls upon the forearm, and finally removes it.

The brachial artery is secured and the nerves cut short. A few vessels which spout are ligatured, and the flaps are then united together over the end of the bone.

The flaps may be made to vary in length with the condition of the parts.

2. Elliptical Method (*Farabeuf*) (Fig. 39, B)

1. *The Incision.*—In this operation the surgeon may conveniently stand on the left of the limb operated upon. Grasping the forearm in his left hand, the surgeon flexes the elbow and rotates the limb towards him until he can conveniently commence the incision over the prominence of the olecranon. From here the incision is made gently curving downwards to a point on the front a little above the middle of the forearm, the arm being rotated away from the surgeon and the elbow gradually extended. The incision curves now over the border of the limb nearest the surgeon, and as the arm is rotated away from the surgeon the elbow is again flexed until the incision is carried back to the starting point at the elecranon.

The incision should be carried a little lower on the outer than the inner side. The flap, which consists only of the integuments, is freed and retracted, shortening the flap in front by an inch and a half.

2. *Division of the Muscles.*—The elbow is then flexed slightly, the operator pinches up the tissues on the front of the elbow, and then entering the knife as near the joint level as he can, he transfixes and divides the muscles. The flap is held back by the assistant while the bones are cleared to the level of the joint, and the disarticulation completed. The radial and ulnar arteries should be found near the free end of the muscular flap, the anterior interosseous on its deep surface. The skin is then sutured over the end of the bone, and the curved cicatrix resulting is on the posterior aspect of the limb.

3. Circular Method (Fig. 39, A)

The skin being well retracted with the left hand, the surgeon passes the knife and his forearm under and well round the injured

limb, and commences the incision with the heel of the knife placed against the nearest border of the limb. The incision encircles the limb two and a half to three inches below the joint level, being a little lower over the outer border of the limb owing to the unequal retraction of the skin. A cuff of skin is rapidly raised and retracted to the level of the joint where the muscles

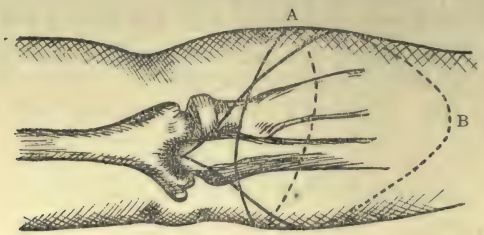


FIG. 39.—AMPUTATIONS OF THE ELBOW.

A, The circular. B, The elliptical.

are divided with firm sweeps of the knife, the joint opened, and the operation completed as before. The edges of the wound may be sewn together transversely or from before backwards. The wound may be drained for 24 hours through a separate hole made in the skin over the olecranon.

4. By Lateral Flaps (Fig. 40, 1)

The surgeon, placing his thumb in the anticubital fossa and the left forefinger at a corresponding point on the back of the limb, cuts lateral flaps two and a half to three inches long according to the relative soundness of the tissues. The flaps are dissected back, consisting of skin and subcutaneous tissue with a few muscular fibres at their base. They are then well retracted, and the muscles divided with circular sweeps of the knife.

The remainder of the amputation is completed as before.

Comment.—All these methods are eminently satisfactory, but the method by lateral flaps is perhaps the least often used.

After-treatment.—The discharge after the operation is considerable, and a tube is best left in for twenty-four hours. The stump should be fixed and supported to prevent twitching.

Amputation through the Arm

Anatomy.—Above the middle of the shaft of the humerus, a point roughly marked by the insertion of the deltoid on the

outer, and the coraco-brachialis muscle on the inner side, the muscles are mostly free from the bone. This freedom of the muscles allows them to retract more than they otherwise would when cut across. Below the middle of the humerus, the muscles, with the single exception of the biceps, are attached to the bone, and are therefore unable to retract to the same extent. The lower half of the arm is the ideal site for circular amputations, while the upper half, on account of this retraction, is quite unsuited for this operation.

The brachial artery in the upper part of its course lies on the inner aspect of the arm in the groove, which marks the inner edge of the biceps muscle. As the artery proceeds down the arm, it passes forwards until it lies in front of the lower end of the bone. The median nerve closely accompanies the artery, lying to its outer side in the upper half, and to its inner side in the lower half of the arm. As a rule, the nerve passes across in front of the artery, but rarely the nerve passes behind the vessel.

The superior profunda is given off soon after the origin of the brachial artery; it accompanies the musculo-spiral nerve round the back of the bone. The inferior profunda arises about the middle of the humerus and accompanies the ulnar nerve to the back of the internal condyle. The anastomotic artery arises about two inches above the bend of the elbow. It is not infrequent for a high division of the brachial artery to be met with.

The ephiphyseal line at the upper end of the humerus is situated just above the surgical neck. The cartilage is not transverse, but caps the peg-shaped upper extremity of the diaphysis as it projects into the interior of the epiphysis. The epiphysis joins with the shaft about the age of 20.

Methods.—

1. Circular.
2. Antero-posterior flaps:
   - A. Skin flaps with circular division of muscles.
   - B. Skin flaps with transfixion of muscles.
   - C. Transfixion flaps.
3. Lateral flaps.
4. Single flap.
5. Teale's method.

Instruments.—The same as for previous amputations. The knife will differ according to the method employed. If transfixion or the circular method be used, a knife with a blade one and a half times the diameter of the limb will be needed.

Position.—The patient lies in the dorsal position, with the arm abducted to a right angle. The surgeon stands on the right of

the limb, *i.e.* outside the right and inside the left arm. An assistant manipulates the hand and forearm, while another controls the main artery.

1. Circular Method (lower half of arm)

1. *Skin Incision.*—Retracting the skin with the left hand, the surgeon passes the knife under and round the arm until the heel of the knife rests on the surface nearest to him, about three inches below the level of the bone section. The circular incision, which only includes the integuments, is made with the whole length of the knife. The assistant in charge of the forearm rotates the limb slightly to meet the knife edge. The skin

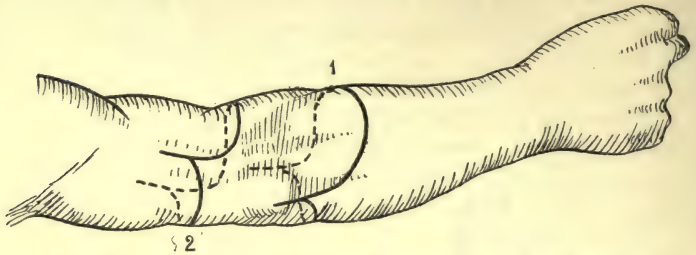


FIG. 40.—AMPUTATIONS OF THE ELBOW AND UPPER ARM.

1, Amputation at the elbow by a long external and a short internal flap. 2, Amputation through the upper arm by long anterior and short posterior flaps.

cuff is dissected up and strongly retracted; care should be taken in freeing the skin along the line of the internal intermuscular septum not to injure the artery.

2. *Division of Muscles.*—When the skin has been retracted for two and a half to three inches the muscles are divided down to the bone with a second circular sweep of the knife. Some surgeons prefer to divide the biceps muscle separately about an inch below the section of the rest of the muscles, as on account of its freedom from the bone it retracts more than the others.

3. *Division of Bone.*—The muscles are then retracted vigorously and the periosteum divided with a third sweep of the knife. Care must be taken to see that the musculo-spiral nerve is cleanly divided, as otherwise it will be ragged with the saw and a painful neuroma ensue. The bone is then divided with the saw. The brachial, superior and inferior profunda vessels are secured with forceps. The median, musculo-spiral and ulna nerves are pulled down and cut short. The vessels are then ligatured, precautions being taken not to include any of the nerves in the

ligatures. Some muscular branches will need a ligature when the tourniquet is removed. The skin flaps are then sewn so that the scar runs from before backwards, a drain being inserted at the posterior angle.

2. Antero-posterior Flaps

A. Skin Flaps with Circular Division of Muscles.—The finger and thumb are placed on the opposite sides of the limb at the level of the bone section. The incision is commenced on the further side of the limb, just below the left forefinger, and an anterior flap marked out equal in length to the diameter of the limb, the incision ending just below the thumb. A similar flap is marked out on the posterior surface of the limb, its length being equal to half that of the anterior flap. In marking out the second flap, the knife is passed under the limb and the incision begun on the further side, as in marking out the first flap. Both flaps should be U-shaped, and their length must vary relatively to each other according to the condition of the tissues. These skin flaps are dissected back. The biceps is cut low down, the other muscles being divided with a circular sweep of the knife at the flap base. The muscles are retracted and the bone divided with the saw. The vessels and nerves are dealt with as in the circular amputation. The method is the same as a circular amputation with the exception of the skin incisions.

B. Skin Flaps with Transfixion of Muscles.—The flaps having been marked out in the same manner as in the preceding operation, the skin is strongly retracted, but is not dissected back. The knife is sent across the front of the bone at the flap-base, the point being made to emerge in front of the vessels. To do this the muscular tissues on the front of the arm are pinched up with the left hand of the operator. A shorter posterior flap of muscles is cut in the same way, the point of the knife emerging behind the vessels. The knife in both cases cuts out through the muscles at the level of the retracted skin. The flaps are then well retracted and the bone cleared as high as possible with a circular sweep of the knife which cuts the remaining muscular tissue together with the vessels and nerves. The bone is sawn through and the operation completed as before. If preferred, the artery may be included in the posterior flap, care being taken that it is not slit up.

C. Transfixion Flaps.—Here the skin and muscle flaps are cut together with great rapidity. The saw line is marked with

the forefinger and thumb of the left hand. The anterior flap is the longer and is cut first. The knife is entered just below the thumb and made to emerge at a corresponding point on the opposite side of the arm. In the case of the left arm the knife enters in front of the vessels, in the right arm it emerges in front of these structures. With a sawing motion the knife is carried down the arm and a well-rounded flap cut. The skin should be cut longer than the muscles by continuing the sawing movement after the muscles are felt to give way. The flap is raised up and the knife entered at the same point as before, but this time passed behind the bone and a shorter flap cut on the posterior surface. The rest of the operation is similar to the last.

3. Lateral Flaps

These are cut in exactly the same way as described for the antero-posterior flaps, the longer flap being taken from the least injured side of the arm. The site of bone section is marked with the forefinger and thumb of the left hand, being placed on the anterior and posterior surfaces of the limb.

The flaps may be cut first and the muscles severed with a circular cut, or transfixed, or, again, the skin and muscles may be cut together by transfixion.

4. Single Flap (*Malgaigne*)

This is a large flap cut by transfixion from the anterior surface of the bone. It should not include the artery.

5. Teale's Method (*see* p. 104)

The large flap is placed on the front and slightly on the outer aspect of the arm, so as not to include the artery, median, and ulnar nerves.

Comment.—In the lower part of the arm the circular operation is the most satisfactory, but is not suitable to the upper part of the limb, the reasons being dealt with in discussing the anatomy of the part. The flap method is applicable to the whole length of the limb and is the operation alone performed above the middle of the bone. Anterior and posterior flaps are preferred to lateral ones, as giving a better covering to the ends of the bone. If possible, the skin flaps should always be marked out first and then the muscles severed either by a circular cut or by transfixion. The method of cutting both skin and muscles together by transfixion is less accurate and has only rapidity to recommend it. Removal of the limb by a single flap or by

Teale's method is very wasteful of the soft tissues, and is to be avoided if possible. The terminal cicatrix resulting from circular amputation is not such a drawback in the upper as in the lower limb, for here the pressure of an artificial limb is taken laterally and not at the face of the stump.

Amputations through the Shoulder Joint

Anatomy.—The prominence of the shoulder is caused by the muscular fibres of the deltoid, which form a pad covering the upper extremity of the humerus. On rotating the arm the tuberosities of the bone can be felt to move underneath the muscular fibres, the small tuberosity in front and the great tuberosity external and slightly posteriorly. The articular head of the bone can only be felt on abducting the bone and feeling in the axilla. It should be remembered that the head of the bone and the internal condyle point in the same direction. The anterior and posterior borders of the deltoid muscle are easy to define. In the groove between the deltoid and the pectoralis major muscles run the cephalic vein and a branch from the acromio-thoracic artery. External to this groove, just below the outer end of the clavicle, and under cover of the innermost fibres of the deltoid, can be felt the tip of the coracoid process, which points almost directly forwards.

The head of the bone lies entirely external to a line drawn vertically through the coracoid process.

Underneath the acromion, coraco-acromial ligament and deltoid, and separating them from the tuberosities, is the large subacromial bursa, forming a species of secondary joint for the upper extremity of the humerus.

Into the great tuberosity the three great external rotators of the arm find insertion, namely, the supra-spinatus, infra-spinatus, and teres minor, in that order from above downwards, the last named wandering a little way on the bone below.

Into the small tuberosity is inserted the subscapularis muscle, under which is a large bursa which frequently communicates with the interior of the joint.

Running between the two tuberosities in the bicipital groove is the tendon of the long head of the biceps surrounded with a prolongation of the synovial membrane of the joint.

To the inner side of the long head of the biceps is the short head of the biceps and coraco-brachialis muscle, and to the inner side of these structures lie the axillary vessels and the large nerve trunks.

The posterior circumflex artery and the circumflex nerve pass round the back of the surgical neck of the humerus about half an inch above the middle of the deltoid muscle, into the deep surface of which the main branches of the vessel pass.

Methods of arresting Hæmorrhage during the Operation.—1. *Compression of the Subclavian.*—The artery is compressed against the first rib above the clavicle either with the thumb of an assistant, or by a specially padded "key." The method is unreliable, difficult to apply, and the assistant is in the way. An incision over the artery has been advocated, digital pressure being applied more directly to the vessel through the incision.

2. *Ligature of the Subclavian or the first part of the Axillary Artery.*—This may be carried out in cases where new growth has extended far up the tissues.

3. *The Elastic Band.*—This is passed across under the axilla and the ends secured above the shoulder or carried across and secured under the opposite axilla. The artery is, by this means, compressed against the head of the bone; as soon, therefore, as disarticulation is completed the band is liable to slip and the vessel escapes.

4. *Wyeth's Pins and Elastic Band.*—Two stout sharp-pointed pins about eleven inches long are used. One pin is inserted in front of the joint, entering at a point just internal to the middle of the anterior axillary fold and emerging within an inch of the tip of the acromion process. The other pin is inserted at a corresponding point posteriorly and also made to emerge within an inch of the tip of the acromion. A strong piece of rubber tubing is next bound round the limb above the pins, which prevent its slipping when the bone is disarticulated.

The best methods are the two following:—

1. The main artery is caught and compressed by the fingers of an assistant, who seizes the flap just before the vessel is divided, its division being one of the last stages of the operation. (*See* Spence's operation.)

2. *Preliminary ligature of the vessels*, by dissecting down to them and securing them before they are divided.

Methods of Operating.—The following operations will be described:

1. Spence's operation.
2. The external or deltoid flap.

Instruments.—A strong-bladed knife with a blade about four inches long. If a transfixion method is to be used a knife with a blade one and a half times the diameter of the limb must be used.

Position.—The patient lies on the back, with the shoulders raised and close to the edge of the table. The face is turned to the opposite side. The affected limb is slightly abducted. The surgeon stands on the outer side of both limbs, but may, if he prefers it, stand on the inner side of the left limb. The assistant stands by the patient's head facing the operator.

1. Spence's Operation (Fig. 41)

Supposing the right arm to be the subject of amputation, the arm is slightly abducted and rotated outwards.

1. *The Incisions.*—A vertical incision, commencing immediately external to the coracoid process, is carried downwards to the level of the humeral attachment of the deltoid. This incision cuts through the clavicular fibres of the deltoid down to the bone. The incision is now carried outwards through the lower fibres of the deltoid, towards the posterior border of the axilla. The whole of this incision has therefore been carried right down to the bone. From the lower part of the vertical incision the knife passes, through the skin and fat only, round the inner side of the arm to join the incision at the outer part. By this shallow incision the vessels and nerves are left intact.

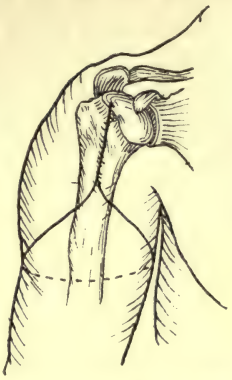


FIG. 41.—SPENCE'S AMPUTATION AT THE SHOULDER.

This is Spence's original method of cutting the flaps when time was of first importance. At the present day the flaps would be marked out by skin incisions only and the vessels exposed and secured by dissecting through the inner part of the incision before proceeding to the next part of the operation.

The outer flap, consisting of the deltoid with the posterior circumflex artery, can now be drawn upwards and outwards, exposing the upper extremity of the humerus.

2. *Disarticulation.*—The tendinous insertions of the capsular muscles, the long head of the biceps, and the capsule are divided by cutting directly on the tuberosities, the limb being rotated inwards to expose the great, and outwards to expose the small tuberosity.

In separating the broad subscapular tendon the edge of the knife must be kept close to the bone for fear of wounding the trunk

of the posterior circumflex artery, as on this vessel the nutrition of the outer flap largely depends.

Disarticulation is then accomplished by abducting the arm, rotating it outwards and then thrusting it upwards until the head is projecting well above the glenoid cavity.

3. *The Inner Flap.*—The surgeon taking hold of the head of the bone, passes the knife behind so as to cut the posterior part of the capsule and then with a sweep of the knife all the soft part on the axillary aspect are divided, the knife emerging at the skin incision previously marked out. If the artery has not already been secured, as the surgeon makes ready to sever the axillary tissues, an assistant grasps the flap with the fingers spread out in the axilla and the thumbs over the main vessel; pressure is kept up till the vessels are secured. The artery is divided between the origins of the posterior circumflex and the superior profunda vessels. The nerve trunks are then cut short and the anterior circumflex artery and muscular branches in the deltoid secured. The edges of the wound are united vertically, drainage being secured at the lower end of the wound.

2. The External or Deltoid Flap

1. *The Incisions.*—The flap may be cut by transfixion, but is better cut by dissection. The surgeon standing outside the limb manipulates it with his left hand. A rounded flap is marked out from the root of the acromion process along the outline of the deltoid to end at the coracoid process. In the case of the right shoulder the incision commences behind, the arm being adducted across the chest. As the incision proceeds the arm is carried away from the chest and slightly abducted. In the case of the left shoulder the incision commences at the coracoid with the arm abducted; as the incision proceeds the arm is adducted across the chest and the incision ends behind.

The inner flap is marked out by an incision involving the skin only, passing transversely across the inner surface of the arm two inches below the outlet of the axilla, joining the first incision in front and behind.

2. *The Outer Flap.*—The outer flap, containing the deltoid, is now raised by deepening the first incision. The flap is drawn outwards and the shoulder joint exposed.

3. *Disarticulation.*—Disarticulation is effected in the manner previously described.

4. *The Inner Flap.*—The head of the bone is then thrust upwards and the knife introduced to its inner side and made to

cut from the bone outwards through the coraco-brachialis, biceps, triceps, axillary vessels and nerves, to emerge at the previously marked skin incision. The artery may be previously dissected out and divided between two ligatures, or the hæmorrhage controlled with the fingers of the assistant grasping the flap. The vessel is severed below the origin of the two circumflex branches. The posterior circumflex vessel will be found cut behind.

Comment.—Of these methods Spence's is infinitely superior to the other as it has the advantage of allowing a preliminary examination of the joint through the vertical part of the incision, and allowing, if necessary, an excision to be carried out in place of an amputation. The deltoid flap is rapid but does not allow of a preliminary examination of the joint.

Inter Scapulo-thoracic Amputation (Fig. 42)

This consists in removing the whole upper limb, including the shoulder girdle, with the exception of the inner third of the clavicle, which is usually left.

Indications.—These are usually the occurrence of sarcomata in the neighbourhood of the shoulder joint, recurrent scirrhus, and gunshot wounds.

Instruments.—A strong amputating knife with a blade about five inches in length, a strong scalpel, retractors, spatulæ, hooks, a key-hole or Gigli's saw, bone forceps, lion forceps, artery forceps, dissecting forceps, periosteal elevators, aneurism needle, scissors, needles, ligature and suture materials.

Position.—The position assumed by the surgeon varies with the different steps of the operation, and will be noted with their description.

Method.—The method of M. Paul Berger will be described, and for convenience it may be divided into four stages.

1st Stage.—The resection of the middle of the clavicle and the ligation of the subclavian vessels at the outer border of the first rib.

2nd Stage.—The formation and reflection of the antero-inferior flap together with the division of the cords of the brachial plexus.

3rd Stage.—The formation and reflection of the postero-superior flap.

4th Stage.—The removal of the limb.

Operation.—*1st Stage.*—The patient lies upon the back close to the edge of the table, with the shoulders slightly raised. The surgeon stands outside the limb facing the patient.

The skin is steadied over the clavicle and an incision down to the bone is made from a point just external to the outer border of the sterno-mastoid muscle outwards to a point just beyond the acromio-clavicular articulation. With a neoplasm in the neighbourhood the superficial veins are likely to be enlarged, the communicating branch from the external jugular to the cephalic will be cut through. A large blunt hook (Treves) is passed round the inner end of the exposed part of the clavicle and the bone divided about the junction of the middle with the inner third, either by a key-hole, or Gigli's wire saw, the deep structures being protected with the blunt hook and the bone steadied with lion forceps. The outer portion of the clavicle is now drawn forwards with the hook and forceps, the subclavous muscle being freed from the posterior surface, and the bone divided about the junction of the middle with the outer third. In this way the middle third of the bone is completely removed, while the inner third is left undisturbed, and the outer third, together with the limb, falls outwards and backwards, increasing the space between the two ends of the bone.

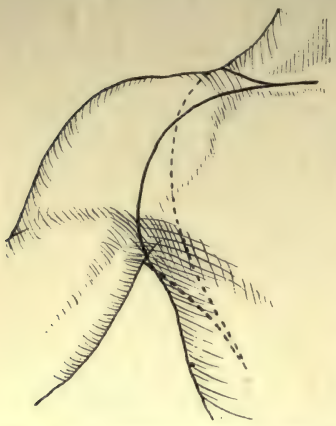


FIG. 42.—INTER-SCAPULO THORACIC AMPUTATION.

The exposed subclavius muscle is now divided carefully close to its inner attachment and thrown outwards. Some layers of the deep cervical fascia are next divided, before the sheath of the vessels and nerves is seen. Although the vein lies in front, and at a lower level than the artery, and therefore is easier of access, the latter should be secured first in order to lessen the amount of blood in the limb at the time of removal. There are two guides to be remembered to the artery, (1) the pulsation of the vessel, and (2) the internal anterior thoracic nerve, which is found at the upper border of the pectoralis minor, emerging from between the artery and vein. A double ligature is passed round each of the vessels, and tied, the vessels being divided between the ligatures. There is great danger of air entering the vein at this stage if the vessel is wounded.

2nd Stage.—With the patient still lying on his back with the shoulder projecting over the edge of the table, the arm is now

abducted from the side and the surgeon takes his stand between the trunk and the limb. The antero-inferior flap (pectoro-axillary) is marked as follows: Commencing at the middle of the clavicular incision, the knife is made to curve outwards above the coracoid process on to the prominence of the deltoid, and passes down to the point where the anterior wall of the axilla joins the arm; here the knife passes round the lower border of the pectoralis major, and transversely across the axillary aspect of the arm. The assistant now raises the arm above the patient's head. The knife now follows the line of the axillary border of the scapula just internal to the prominence formed by the teres major and latissimus dorsi muscles, the tendons of which the knife has crossed higher up.

This incision only divides skin and fascia; now the flap marked out is dissected up. The pectoralis major is divided where the knife has crossed it, the pectoralis minor just internal to the coracoid process.

The flap is now fully retracted and the cords of the brachial plexus exposed, these are now divided near the outer border of the first rib.

3rd Stage.—With the patient still in the same position, the limb is carried across the trunk to the opposite side, rolling the patient on to the sound side, so as to expose the scapular region fully. The surgeon stands on the affected side facing the head of the table. The postero-superior (cervico-dorsal) flap is marked out as follows: From the outer end of the clavicular incision (*i.e.* from a point just external to the acromio-clavicular articulation) the knife is taken by the shortest route to join the extremity of the antero-inferior flap over the inferior angle of the scapula. Nothing but the skin and fascia are divided by this incision. Next the flap is dissected up, and the trapezius muscle is divided near its insertion to the clavicle and scapula.

4th Stage.—All that remains now is the division of the various structures which still connect the scapula to the trunk. The surgeon stands on the outer side of the left arm and on the inner side of the right. The limb will need manipulating so as to bring the various structures under the knife in the most convenient way. The following structures need division, the omo-hyoid, levator anguli scapulæ, rhomboids minor and major, the serratus magnus, and the latissimus dorsi muscles. During this stage the supra- and posterior scapular vessels will have to be dealt with. The limb is then free from the body. The bleeding points are secured, and all tissue likely to be affected is cleared away; the pectoral muscles are best removed in malignant disease.

The wound is stitched up, a drain is placed in the lower angle or through a specially made opening. Firm pressure is necessary to prevent the accumulation of discharges in the large pocket which is left.

In favourable cases the patient can be made to sit up in two or three days. The patients experience a marked feeling of lop-sidedness, and have a difficulty in balancing themselves during the early days of convalescence.

Dangers : *Hæmorrhage.*—If the main vessels have been secured early, little hæmorrhage is met until the fourth stage of the operation is reached, when vessels which arise from the first part of the subclavian artery may give trouble. During the fashioning of the antero-inferior flap some hæmorrhage may be met with from the branches of the acromio-thoracic artery, long thoracic, and from muscular branches, the blood reaching these by the anastomosis round the scapula.

Air Entering the Veins.—This is a serious danger during the first part of the operation; the veins should all be carefully secured before division.

AMPUTATIONS—LOWER LIMB

Amputation of Toes

A great deal of what has been said in relation to the anatomy of the digits of the hand will be found to apply to those of the foot, and need not be repeated. Amputations through the phalanges or the interphalangeal joints, except in the case of the great toe, are not recommended, the stumps left being of little use in locomotion and inconvenient from their liability to hyper-extension.

The metatarso-phalangeal joints lie an inch behind the level of the web of the toes. As the weight of the body is very largely borne on the heads of the metatarsal bones, these should be interfered with as little as possible. The same care, to prevent the access of sepsis to the tendon sheaths, should be taken here as in dealing with the fingers.

Amputation through the Phalanges or Interphalangeal Joints of the Great Toe

These may be performed in accordance with the directions given for amputations on the fingers (*see* p. 90).

Amputation of the Smaller Toes at the Metatarso-Phalangeal Joints

This is performed in the same manner as is laid down in the case of the fingers, and is best carried out by the racket method.

The knife is entered two-thirds of an inch above the joint line, opposite the neck of the metatarsal. The head of the metatarsal bone is left *in situ*, and a scar free from pressure is the result.

In the case of the great toe the large size of the head of the metatarsal together with its sesamoid bones must be remembered. The oblique portion of the racket should reach down below the web. It is a good plan to make the flap of the racket on the inner side considerably longer than on the outer, thereby ensuring that the scar will be well away from boot pressure.

Amputation of a Toe together with its Metatarsal Bone

Removal of a toe with its metatarsal bone is sometimes performed in the case of the great toe, rarely in the case of the little toe, and almost never in the case of the remaining toes.

Removal of the Great Toe together with its Metatarsal Bone.—This is best performed by the racket method. The exact level of the tarso-metatarsal joint being made out, the incision is commenced on the inner border of the foot just below this level. The incision is carried outwards on to the dorsum of the metatarsal bone down which it proceeds, lying to the inner side of the tendon of the extensor proprius hallucis. Below the middle of the metatarsal bone the incision inclines still further outwards to the web of the toe. It next passes across the plantar aspect of the toe at its root, and finally ascends to join the dorsal incision at the middle of the metatarsal bone. This incision divides the skin only.

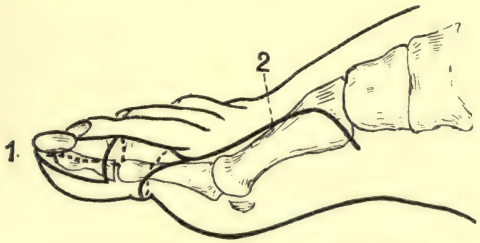


FIG. 43.—AMPUTATION OF BIG TOE.

1, Amputation of terminal phalanx. 2, Amputation of big toe and metatarsal.

By deepening the dorsal incision, the back of the bone is cleared, care being taken to keep the edge of the knife close to the bone. The lateral and plantar portions of the incision are deepened and the bone dissected out in the same way as is described in the corresponding operation on the thumb. The joint is opened from the dorsum. The dorsalis pedis artery is

scrupulously avoided as it dips down at the proximal end of the first interosseous space, to join the deep plantar arch. The sesamoid bones are left behind.

Amputation of the Little Toe together with its Metatarsal Bone.—This is carried out in identically the same way by a similar incision placed on the outer side of the foot.

Amputation through the Tarso-Metatarsal Joint

Disarticulation at this joint is rarely performed on the living subject. It is chiefly performed on the cadaver, and is a favourite operation in examinations. The indications in the living subject are (1) limited crushes where the sole is sound ; (2) disease limited to the front of the foot ; (3) perforating ulcer ; (4) frost-bite.

Anatomy.—The line of the tarso-metartasal joint extends nearly one inch further forwards on the inner than on the outer side of the foot. The line of the joint can be easily defined with the thumb nail on the inner side of the foot, while on the outer side the styloid process of the fifth metatarsal is a prominent landmark. Between these two points, the line of the joint has a very irregular course, owing to the fact that the base of the second metatarsal extends backwards between the internal and external cuneiform bones. The joint between the second metatarsal and the middle cuneiform is nearly half an inch behind that between the first metatarsal and the internal cuneiform, and nearly a quarter of an inch behind that between the third metatarsal and the external cuneiform bone.

The tarso-metatarsal joint line is really made up of three separate joints. First, the joint between the first metatarsal and the internal cuneiform ; secondly, that between the second and third metatarsals and the three cuneiform bones ; thirdly, that between the fourth and fifth metatarsals and the cuboid.

The joint between the first metatarsal and the internal cuneiform has a complete capsular ligament, very thick on the plantar and inner aspects. There is a separate synovial membrane for this joint.

The joint between the second and third metatarsals and the three cuneiforms has the following ligaments : Dorsal, between the bases of the metatarsals and the cuneiforms. Plantar passing from corresponding points on the plantar surfaces of the bones, the strongest of which converge on the base of the second metatarsal. Interosseous, the most important of which passes from the outer surface of the internal cuneiform to the inner surface of the base of the second metatarsal, and shuts off this

joint on the inner side. It is this ligament which renders dislocation of the base of the second metatarsal so difficult. A less important interosseous ligament passes forward from the external cuneiform to the bases of the third and fourth metatarsals, and limits the joint on the outer side.

The synovial membrane of this joint is common to the scapho-cuneiform and inter-cuneiform joints.

The cubo-metatarsal joint is furnished with a capsular ligament made up of dorsal, plantar, external, and interosseous fibres. It possesses a separate synovial cavity.

The dorsalis pedis artery dips down at the proximal end of the first interosseous space to complete the deep plantar arch. The deep plantar arch passes obliquely across the bases of the second and third metatarsals.

The peroneus longus and a slip from the tibialis anticus are inserted into the base of the first metatarsal; the peroneus brevis and tertius into the base of the fifth metatarsal.

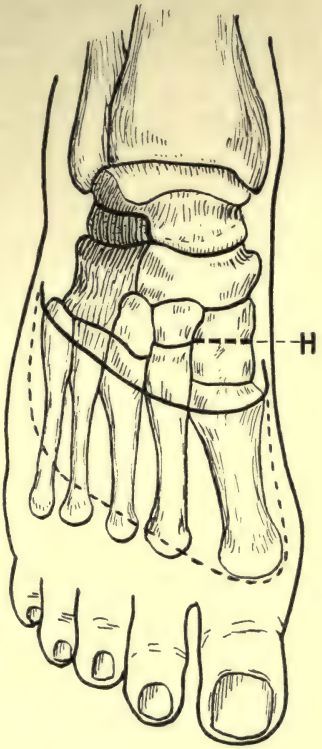


FIG. 44.—LISFRANC'S AMPUTATION.

H, Saw line in Hey's modification.

Lisfranc's Operation

Instruments.—A stout knife with a narrow blade about four inches long. If the foot has been crushed, a pair of lion forceps will be useful.

Position.—The patient lies on the back with the foot raised and projecting well beyond the end of the table. The surgeon stands facing the foot of the table. The assistant stands on his right side.

Operation.—1. *The Incisions.*—The surgeon grasps the foot (right) with the left hand, placing the forefinger and the thumb over the joints at the bases of the fifth and first metatarsals respectively, the palm of the hand lying against the heel. A

dorsal incision, slightly curved with the convexity forwards, is made from the forefinger to the thumb.

The plantar flap is marked out, commencing at the outer end of the first cut, and passing up the outer border of the foot, then across the heads of the metatarsals, and down the inner border of the foot, terminating at the inner end of the dorsal incision.

The plantar flap is longer on the inner side than on the outer, owing to the conformation of the foot. This is needed as the bones project more on the inner side.

2. *The Dissection of the Flaps.*—The assistant now holds the foot in the dorsiflexed position while the surgeon dissects up the plantar flap, using his left hand as a retractor. The flap is

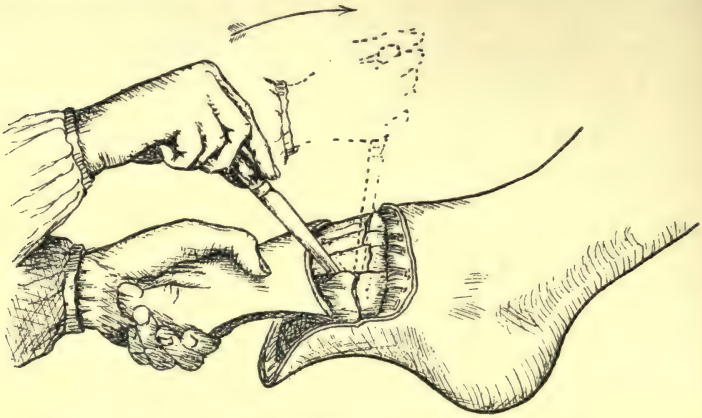


FIG. 45.—LISFRANC'S AMPUTATION.

The flaps having been dissected up, the hand is shown passing the point of the knife between the bases of the first and second metatarsals. The dotted hand shows the position of the hand and knife at the end of the *coup de maître*, by which the interosseous ligament is divided.

dissected up and contains all the plantar tissues down to the bones, it is raised up as far as the bases of the metatarsals. The prominent bases of the first and fifth metatarsals must be cleared, the peroneus longus and the slip from the tibialis anticus being separated from the former. The dorsal incision is deepened down to the bones, severing the extensor tendons.

3. *The Disarticulation.*—The anterior part of the foot is strongly depressed, and the dorsal ligaments rendered tense. The knife is carried round the base of the fifth metatarsal, and cuts forwards and inwards in the line of the joint as far as the base of the second metatarsal.

The joint between the first metatarsal and the internal cuneiform is next opened. The base of the second metatarsal is freed

as follows. The knife, with the edge uppermost, and the blade held nearly parallel with the dorsum of the foot, is thrust deeply between the first and second metatarsal bones. The knife is then grasped in the fist like a dagger, and the handle elevated to the perpendicular as it is made to cut towards the ankle. The same manœuvre may be repeated between the second and third metatarsals. By this means the strong interosseous ligaments which hold the base of the second metatarsal in place are severed. The foot is strongly depressed and the joint between the base of the second metatarsal and the middle cuneiform is opened with the point of the knife. The disarticulation is now complete, and a few touches of the knife will suffice to free the part.

The dorsalis pedis artery and the external plantar arteries, with a few smaller twigs, will need to be secured. The plantar flap is then sewn up over the stump, drainage being secured on each side. In dealing with the left foot the incisions are begun on the inner border. Disarticulation is commenced on the inner side.

Comment.—Some surgeons recommend that a short dorsal flap about three-quarters of an inch long be marked out in all cases. This is dissected up before marking out the plantar flap, and contains all the structures down to the bones.

After marking out the dorsal flap disarticulation may be at once proceeded with. When this is accomplished the knife is introduced behind the bases of the metatarsals and the plantar flap cut from within outwards. This is difficult and has little to recommend it, the plantar tissues are in danger of being perforated. In disarticulating the assistant should hold the plantar flap out of the way of injury.

Care must be exercised not to carry the incision far above the line of the joint on the inner border of the foot or the joint between the scaphoid and cuneiform bones may be opened by mistake.

If the foot is depressed too vigorously during the disarticulation of the second metatarsal, that bone may fracture and difficulty be met with before the fragment is removed.

In the living subject it is simpler and more rapid to saw through the bases of the metatarsals than to disarticulate. This can nearly always be done and preserves some of the tendinous insertions.

The plantar flap is heavy, stiff, and tends to fall away from off the end of the stump. To prevent this many sutures taking a deep grip of the tissues should be employed.

Hey's Operation

This differs from the foregoing operation very slightly. The joint between the internal cuneiform and the first metatarsal is not opened, but after disarticulating the four outer metatarsals the projecting end of the internal cuneiform is sawn off and removed attached to the base of the first metatarsal bone.

Amputation through the Transverse Tarsal Joint

Anatomy.—The line of the transverse tarsal joint runs from just behind the prominent tubercle of the scaphoid on the inner side, to a point mid-way between the tip of the external malleolus and the styloid process of the fifth metatarsal on the outer side of the foot. It consists of two articulations; an inner one between the head of the astragalus and the scaphoid, and an outer one between the os calcis and the cuboid. The line of the astragalo-scaphoid joint is a little in advance of that of the calcaneo-cuboid joint.

The astragalo-scaphoid joint is surrounded by (1) the thin astragalo-scaphoid ligament on the dorsum; (2) the inferior calcaneo-scaphoid ligament, a thick fibrous plate which supports the head of the astragalus on the plantar aspect; and (3) the external calcaneo-scaphoid ligament externally, which shuts this joint off from its neighbour. The synovial membrane is common to it and to the anterior astragalo-calcaneal joint.

The calcaneo-cuboid joint is surrounded by (1) and (2) the dorsal and the external calcaneo-cuboid ligaments on the dorsal and external aspects of the joint respectively; (3) and (4), the long and short plantar ligaments on the plantar aspect of the joint.

The synovial cavity is confined to this joint alone. The line of the dorsalis pedis artery is from a point in front of the ankle, mid-way between the two malleoli to the proximal end of the first interosseous space.

The extensor tendons to the toes and peroneal tendons lie on the dorsum of the articulation. The tendon of the tibialis posticus is attached chiefly to the tubercle of the scaphoid, the tendon of the peroneus longus lies in a groove on the outer and under surfaces of the cuboid.

Chopart's Amputation

Instruments and Position.—The same as in Lisfranc's operation.

Operation.—1. *Incisions.*—The surgeon grasps the foot (right) with the left hand, placing the forefinger and thumb just behind the calcaneo-cuboid and astragalo-scaphoid joints respectively,

the palm of the hand against the sole. The dorsal incision, commencing on the outer side, is made in a curved line between these two points, the convexity being forwards over the tarsus. This incision divides everything down to the bone. The plantar incision, commencing on the outer side, passes up the outer

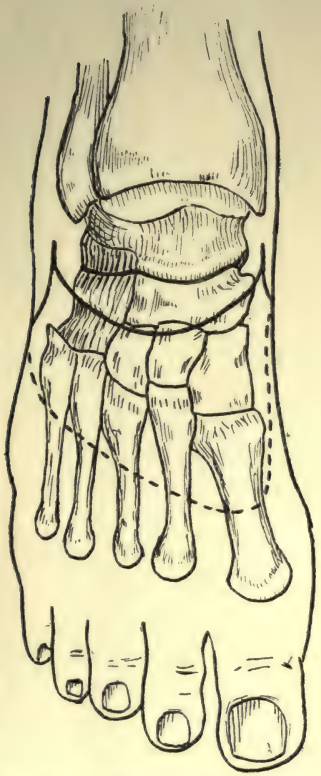


FIG. 46.—CHOPART'S AMPUTATION.

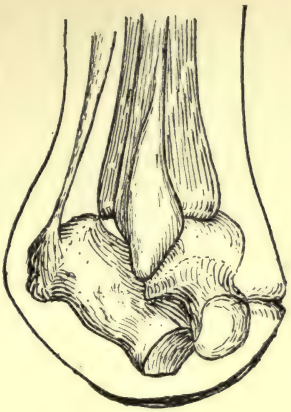


FIG. 47.—STUMP AFTER CHOPART'S AMPUTATION, SHOWING TILTING UP OF HEEL, AND FORWARD DISLOCATION OF ASTRAGALUS.

border of the foot, crosses the sole about the middle of the metatarsus, and finishes by passing down the inner border of the foot to the inner end of the dorsal incision. This incision follows the main lines of Lisfranc's plantar flap, but is a full inch shorter.

2. *Dissection of the Plantar Flap.*—The assistant fixes the foot in a dorsi-flexed position, while the surgeon holds the flap in his left hand. The flap is dissected up in the same way as in Lisfranc's operation, and contains all the tissues down to the bones, as far back as the transverse tarsal joint.

3. *Disarticulation.*—The flap is retracted and the foot depressed. Disarticulation is commenced by inserting the knife, held nearly vertically with the point up, behind the tubercle of the scaphoid and cutting outwards. It should be remembered that the knife has to pass round the ball-like head of the astragalus. The calcaneo-cuboid joint is next opened and the disarticulation completed. In the dorsal flap the dorsalis pedis, the tarsal, and metatarsal arteries must be secured. In the plantar flap the internal and external plantar and some digital branches of the latter will be found.

The heavy plantar flap is then folded up over the end of the bones and fixed with sutures, which should take a large amount of tissue in their grip.

Comment.—Care must be taken to insert the knife behind, and not in front of, the tubercle of the scaphoid, as the joint between the first metatarsal and the internal cuneiform may be opened by mistake and the scaphoid left behind. This is a common mistake.

There are objections to the operation, and its value is questioned for the following reasons :—

1. The weight of the body tends to thrust the astragalus forwards and downwards, while the unopposed tendo-Achillis draws up the os calcis. Thus the scar comes to be pressed on, and a tender stump results.

2. If tubercular disease of the tarsus was the cause of the operation, the disease is very likely to recur in the two bones left. A Syme's amputation is therefore preferable.

To prevent the drawing up of the os calcis and the downward tilting of the stump many suggestions have been made.

1. To suture the extensor tendons to the deep surface of the plantar flap ; this is a rational proceeding and does good.

2. Section of the tendo-Achillis; this is only a temporary remedy.

3. Wearing a wedge-shaped pad in the boot.

4. Leaving the scaphoid with the attachment of the tibialis posticus undisturbed. There is no evidence to show that this modification is of any value.

Tripier's Operation (Figs. 48 and 49)

This is devised to prevent the forward displacement of the astragalus by sawing the os calcis horizontally and providing a flat surface of bone on which the weight is borne. The incisions are as follows : The dorsal incision starts from near the outer margin of the tendo-Achillis on a level with the tip of the external malleolus; from

here it passes in a curved manner downwards and forwards one and a quarter inches below the external malleolus to about the same distance from the base of the fifth metatarsal, and then sweeps over the dorsum of the foot to reach the tendon of the extensor proprius hallucis two fingers' breadth in front of the ankle joint.

The plantar incision starts where the dorsal ended, and passing downwards and forwards over the joint between the great toe and the internal cuneiform, it sweeps across the sole under the bases of the metatarsals and joins the dorsal incision on the outer side of the foot.

The incisions divide everything down to the bone. The flaps are dissected back and the foot disarticulated, as in Chopart's operation. The heel flap is then separated from off the os calcis till the sides and under-surface are bare. The saw is then applied on the inner surface of the bone, which is divided in a horizontal manner, just below the sustentaculum tali.

The sharp angles of the bone are rounded off and the flaps united.

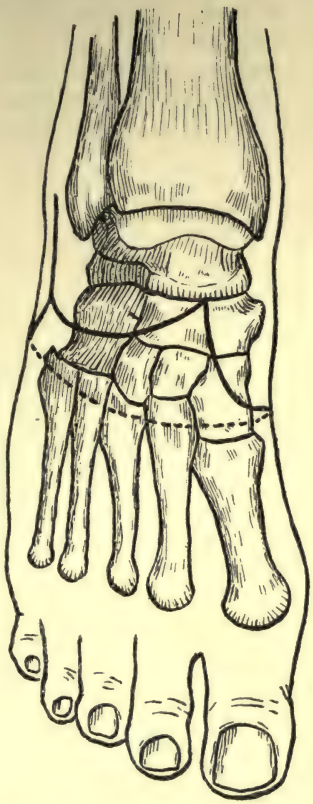


FIG. 48.—TRIPIER'S MODIFICATION OF CHOPART'S AMPUTATION.

Disarticulation through the Astragalo-Calcaneal Joints

(*Subastragaloid articulation*)

Anatomy.—Between the astragalus and calcaneum there are two joints, one situated in front of the other and separated from each other by a very powerful interosseous ligament. This interosseous ligament forms the chief bond of union between the two bones. It is situated in a deep groove which runs forwards and outwards, on the opposing surfaces of the bones.

The posterior astragalo-calcaneal joint has a separate synovial membrane. The anterior astragalo-calcaneal joint has a synovial membrane in common with the astragalo-scaphoid articulation. From the upper surface of the os calcis in front of the interosseous groove, the prominent sustentaculum projects on the inner side. This process can be felt one inch below the tip of the internal malleolus, and one and a quarter inches behind the tubercle of the

scaphoid. Just above the level of the sustentaculum tali is the astragalo-calcaneal joint, while immediately below it runs the tendon of the tibialis posticus, passing from behind the malleolus to the tubercle of the scaphoid.

Method.—By an external racquet-shaped incision (*Maurice Perrin*) (Fig. 50).

Position and Instruments.—The same as in Lisfranc's operation.

Operation.—1. *The Incision.*—An incision commencing on the outer side of the heel, about one inch below the tip of the external

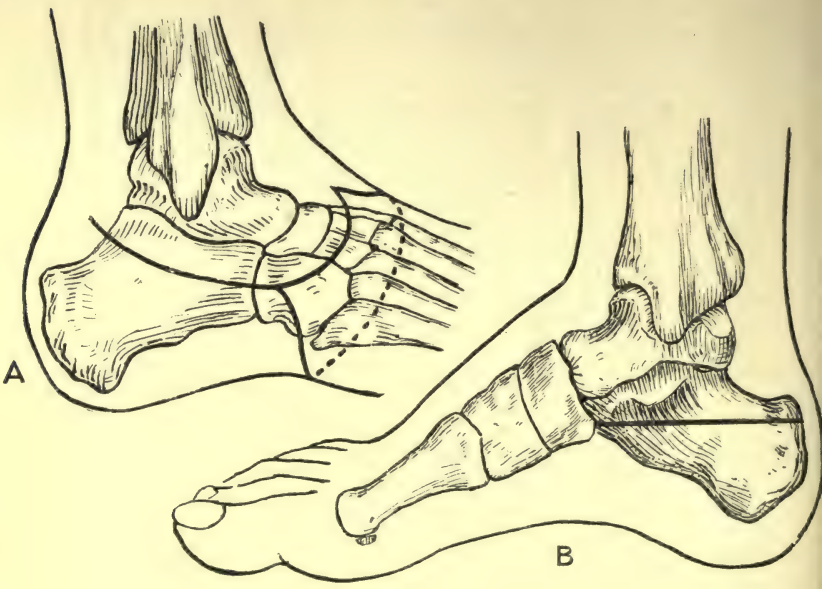


FIG. 49.—TRIPIER'S MODIFICATION OF CHOPART.

A, Skin incision. B, Saw cut: lower piece of os calcis removed (*cf.* Fig, 53).

malleolus, is carried forwards to the base of the fifth metatarsal bone, thence curving forwards across the dorsum of the foot to reach to the base of the first metatarsal. From here the incision curves across the sole of the foot to join the first opposite the calcaneo-cuboid joint. The soft parts are divided down to the bone. The flap is dissected back, exposing the cuboid and outer surface of the os calcis externally, the head of the astragalus in front, and the tubercle of the scaphoid internally. The tendons of the peronei and tibialis anticus are cut and the anterior part of the internal lateral ligament of the ankle joint divided.

2. *Disarticulation.*—The anterior part of the foot is depressed and inverted. The astragalo-scaphoid joint is freely opened. The knife is then made to cut along the under surface of the astragalus till the interosseous ligament is divided. The foot is then turned well inwards, and, keeping the edge of the knife close to the bone to avoid injury to the vessels, the tissues on the inner side of the os calcis are dissected off and the tendo-Achillis divided at its insertion. The dissection of the tissues from the inner side of the os calcis is the most difficult part of the operation.

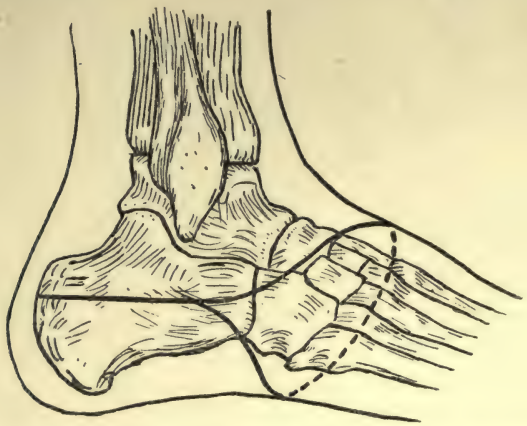


FIG. 50.—SUBASTRAGALOID AMPUTATION BY THE METHOD OF MAURICE PERRIN.

The posterior tibial nerve, which is found lying to the outer side of the artery, must be dissected up and cut short in order to escape pressure. In the upper part of the flap branches from the anterior and posterior peroneal vessels, the tarsal, the metatarsal, and dorsalis pedis arteries will need securing. In the lower part the internal and external plantar arteries are found.

When the margins of the wound are united the suture line is horizontal on the front and outer aspect of the stump.

Farabeuf's Method (Fig. 51)

For this operation Farabeuf devised a large internal and plantar flap as follows. The incision commences at the outer border of the tendo-Achilis and curving upwards slightly, it passes horizontally forwards one inch below the external malleolus

almost to the base of the fifth metatarsal. From here it sweeps across the dorsum of the foot in a line a little in advance of the scapho-cuneiform articulation as far as the tendon of the extensor proprius hallucis. Then passing round the inner border of the foot at the level of the joint between the first metatarsal and the internal cuneiform it sweeps across the sole to follow the outer margin of the foot back to the external tuberosity of the

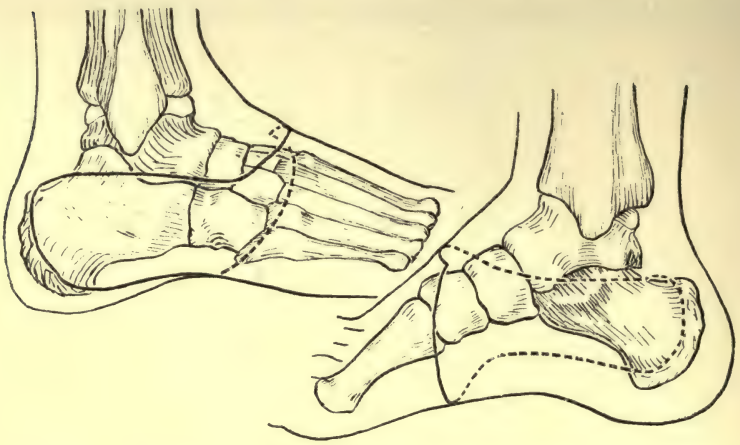


FIG. 51.—INCISIONS FOR FARABEUF'S SUBASTRAGALOID AMPUTATION.

os calcis, and then turns upwards to the starting point. The operation is performed as above described, and is rather easier to carry out.

Amputation through the Ankle Joint (Syme's Operation)

Anatomy.—This amputation is performed through the ankle joint, the articular surface of the tibia with the two malleoli being sawn off subsequently. The weight of the body is borne by the tough tissues forming the heel which caps the end of the stump.

Instruments.—A Syme's amputation knife, which is a stout, narrow knife with a blade about three inches long.

Position.—The patient lies on the back with the foot raised and projecting well beyond the end of the table. The surgeon stands facing the foot while an assistant stands on one side and holds the foot at a right angle to the leg.

Operation.—1. *The Incisions.*—"The incisions must be correctly made. A transverse one should be carried across the sole of the foot, from the tip of the external malleolus, or a little posterior to it (rather nearer the posterior than the anterior edge of the bone), to the opposite point on the inner side, which will be rather below the tip of the internal malleolus" (*Syme*). (*See* note, p. 134.) The incision ends about half an inch

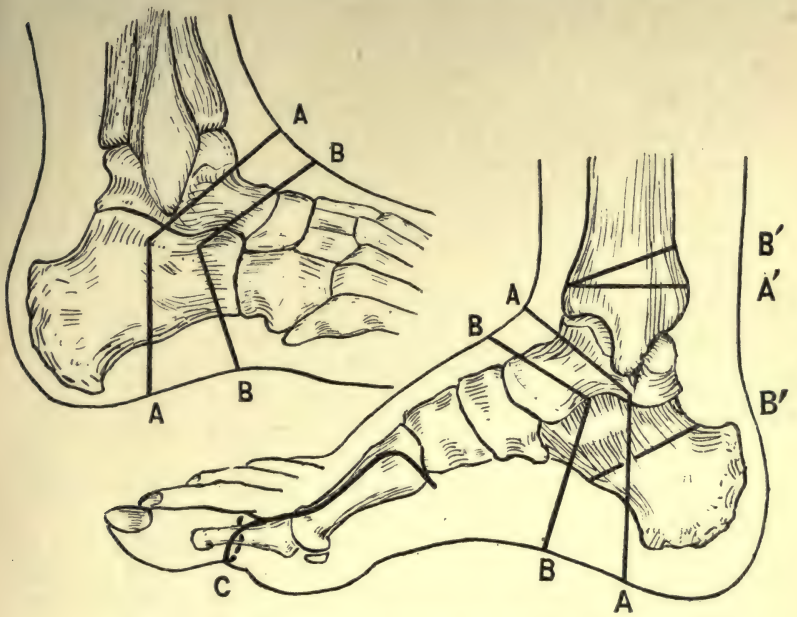


FIG. 52.—SYME'S AND PIROGOFF'S AMPUTATIONS.

A and A′, Syme's amputation and saw cut. B and B′, Pirogoff's amputations and saw cut. C, Amputation of big toe and metatarsal.

below the tip of the internal malleolus, so that the inner part of the flap is a little larger than the outer.

The dorsal incision connects the two points already indicated by the shortest route. Both incisions sever everything right down to the bones.

2. *The Heel Flap.*—The assistant now steadies the foot in a dorsi-flexed position, while the surgeon, using his left thumb as a retractor, commences to reflect the heel flap. The edge of the knife must always be kept directed towards the bone, especially must this be the case on the inner side, where the vessels lie in close contact with the bone. Considerable force is needed to

turn the flap over the point of the heel. The flap is freed from the posterior surface of the os calcis, the edge of the knife still clinging to the bone.

3. *Disarticulation.*—The foot is depressed and the anterior ligament of the ankle cut. The point of the knife is inserted into the joint, and the lateral ligaments cut from within outwards, care being taken not to wound the posterior tibial artery behind the inner ligament. The foot is still further depressed and twisted from side to side as the posterior ligament and the tendo-Achillis are cut through. The foot is then free and is removed.

4. *Romoval of the lower ends of the Tibia and Fibula.*—The soft parts are well retracted by the assistant as the tissues are freed from the surfaces of the two malleoli. The knife is passed round both bones so as to divide the periosteum just above the level of the articular cartilage. Here again the position of the posterior tibial artery must be borne in mind. The saw is then applied, and the malleoli and articular surfaces of the tibia and fibula removed.

The anterior tibial artery is found in the middle of the flap in front, its internal and external malleolar branches may be found one on each side. The internal and external planter arteries are found close together at the free margin of the heel flap. The internal malleolar from the posterior tibial will also have to be secured.

The heel flap is then folded up over the ends of the bones and secured in position, drainage being allowed at each side.

Comment.—The stump which results, consisting as it does of the natural tissues of the heel, is admirably suited to bear the pressure of the weight of the body. The tendons form attachments to the cicatrix and a movable stump results.

Too much stress cannot be laid on the importance of not wounding the posterior tibial artery, on which the vitality of the heel flap so largely depends.

If preferred, after the primary incisions have been made, disarticulation may be proceeded with, and the os calcis enucleated from the heel from above downwards. In an examination, if a candidate be asked to perform Syme's amputation he runs considerable risk in attempting to perform it in any but the orthodox way. In young subjects the posterior epiphysis of the os calcis may safely be left in the heel flap.

If the choice lies with the student, he should always perform this operation on the *left* foot.

NOTE.—In some books the starting points of the incisions are very carelessly given and it is advised that the incision be carried from the tip

of the outer malleolus to a point half an inch below and *behind* the tip of the internal malleolus. If this advice be followed there is a great risk of dividing the posterior tibial artery before its bifurcation, and thus the internal calcaneal branch of the external plantar, which is the main vessel to the heel flap, may be lost. The directions given above are in Syme's own words.

Pirogoff's Operation (Fig. 52)

This differs very little from that of Syme. The os calcis is sawn through obliquely so as to leave the hinder end, the raw surface of which is applied to the sawn surface of the tibia and fibula.

The incisions pass between points situated just in front of the two malleoli, the heel flap is larger, being carried further forward than in Syme's operation. The dorsal incision is more curved, passed further down the front of the ankle.

The heel flap is dissected back about half an inch. Then the ankle joint is opened from the front and the foot depressed until the upper surface of the astragalus is completely dislocated, the heel flap is retracted and a saw applied to the upper surface of the os calcis behind the astragalus, and the bone sawn through. The lower ends of the tibia and fibula are cleared and sawn off, the saw line slanting a little upwards and backwards.

The heel flap is folded up and fixed, the raw surfaces of the bones being in apposition.

Le Fort's Operation (Fig. 53)

The amputation is performed by means of a racket-shaped incision, and the os calcis sawn through horizontally. The incisions are as follows :—

Starting from near the insertion of the tendo-Achillis on the outer side of the heel, the knife passes forwards three-quarters of an inch below the external malleolus to the anterior third of the os calcis. From here it is made to sweep over the dorsum of the foot just in front of the astragalo-scaphoid joint to a point one inch in front and below the internal malleolus. Thence the knife passes in a curved manner across the sole of the foot to join the dorsal incision below the external malleolus. The soft parts are dissected up from the outer and front aspects of the foot.

The ankle joint is opened in front and on the outer side, the foot being twisted strongly inwards, the astragalus is dislocated and the inner surface of the bone cleared. The saw is applied to the inner surface of the os calcis just below the sustentaculum tali, and the bone sawn horizontally. The foot is now disarticulated at the calcaneo-cuboid joint and removed. The lower ends

of the tibia and fibula are sawn off as in Syme's operation. The edges of the wound are brought together, a horizontal scar on the front and outer aspects of the stump resulting, the sawn surfaces of the bones being in close apposition.

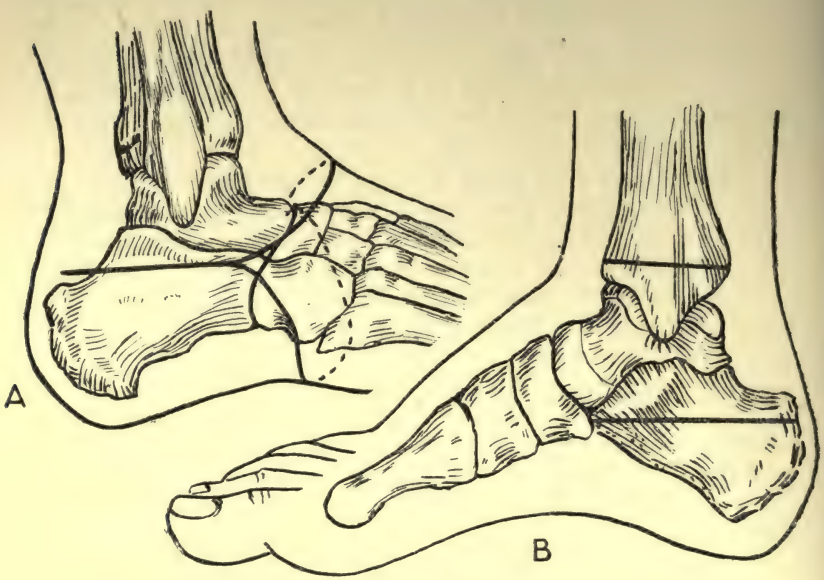


FIG. 53.—LE FORT'S AMPUTATION (A MODIFICATION OF SYME).

A, Incision. B, Saw cuts: upper half of os calcis removed (*cf.* Fig. 49).

Amputations through the Leg

Amputations of the leg differ from those of the foot in that the end of the stump is not called upon to bear the weight of the body. Broadly speaking, *the end of no amputation stump above the level of a Syme is able to bear the constant weight of the body.* Amputation stumps between the level of Syme and the site of election, a hand's breadth below the level of the knee, all need carefully moulded sockets, so that the pressure is distributed over the sides of the leg and the bony prominences below the knee. Artificial limbs such as these are expensive, and unsuited for rough work. For this reason amputations between these two points are rarely seen in hospital patients.

Anatomy.—In the upper third of the leg, the bones are well surrounded by muscles, except the inner surface of the tibia, which is subcutaneous. At this level all the muscles with the

exception of the gastrocnemius and the unimportant plantaris, are attached to the bones of the leg and the interosseous membrane. Retraction of the muscles therefore will be limited except in the case of the gastrocnemius, the section of this muscle in consequence should be placed at a lower level than that of the others or an unsightly and conical stump will result. With this precaution a circular amputation may be performed at this level, and a good stump obtained. The anterior tibial artery lies on the front of the interosseous membrane, between the tibialis anticus and the extensor longus digitorum; the nerve lies a little to the outer side of the artery. At the site of election, the posterior tibial artery has just given off its peroneal branch, and the two lie close together bound down by fascia to the tibialis posticus under cover of the superficial muscles of the calf. The posterior tibial nerve lies to the inner side of the artery crossing behind it at a lower level.

In the lower part of the leg, the muscular bellies have in most instances given place to tendons which are free from the bones and capable of retracting considerably. Circular amputation therefore is inadmissible at this level, as a conical stump would result.

A great many methods of operating have been applied to this area, but for practical purposes only three will be mentioned, namely, amputation by Teale's method, amputation by a long posterior and short anterior flaps, and amputation by lateral flaps with circular division of muscles. The last-mentioned of these methods is fully described at the site of election, so that there is no need to give it here.

Methods.—The following methods are described in this order.

1. Below the level of the site of election—
   (1) Teale's amputation.
   (2) Long posterior and short anterior flaps.
2. At the site of election a hand's breadth below the level of the knee—
   (1) Large external flap (Farabeuf).
   (2) Lateral flaps with circular division of muscles.
   (3) Circular method.

Instruments.—An amputating knife with a blade from four to five inches long—for the circular method a longer knife is required—an amputating saw, and suitable retractors.

Sawing the Bones.—If the bones of the leg are sawn across transversely, the anterior margin of the tibia which forms a sharp angle, would tend to produce ulceration on pressure being applied to the anterior surface of the stump. To avoid this, the

anterior sharp angle is removed and the bone rounded off in the following manner. The soft parts being well retracted above the line of division, the saw is made to engage the anterior border of the tibia about half to three-quarters of an inch above the level where the bones are to be divided. The saw is held obliquely so as to cut downwards and backwards, and the section continued about half through the bone. The instrument is now withdrawn from the saw-cut, and the bone sawn squarely through half to three-quarters of an inch lower down. The section being transverse travels across the previously made oblique saw-cut, and the angle of bone falls out. When the tibia is half sawn through, the handle of the saw is depressed or raised according to which limb is being operated upon, and the saw is made to engage the fibula. The section of the fibula is completed first, or both bones may be finished together.

Position.—The patient lies on the back with the leg projecting well beyond the end of the table. The surgeon stands on the right of the leg operated upon, one assistant stands opposite him while another manipulates the leg and foot.

Below the level of the Site of Election

(1) **Teale's Amputation by Rectangular Flaps** (at the junction of the middle and lower thirds of the leg)

Two rectangular flaps are marked out accurately on the skin before the incisions are commenced. The anterior equals in length and breadth half the circumference of the limb at the level of the saw line. The posterior flap is only a quarter the length of the anterior (Fig. 54, A).

1. *Incisions.*—The circumference of the limb being ascertained already, the surgeon places the forefinger and thumb of the left hand on the tibia and fibula respectively (right leg), at the level of the future saw line. The knife is entered close to the forefinger on the side of the limb furthest from the surgeon and travels straight down the limb for the required distance (half the circumference of the limb at the saw-cut). From here the knife sweeps transversely across the front of the limb, and then passes straight up to the thumb on the side of the leg nearest the surgeon. In the lower third of the leg, where the limb narrows rapidly, it is important to remember that the width of the *free end* of the flap must equal the width of *the base*—half the circumference of the limb at the saw-cut, hence the advisability of *marking* the flap beforehand. The posterior flap is cut by the surgeon looking over the limb and making a transverse cut

across the back of the leg from one vertical incision to the other, the posterior flap being one quarter the length of the anterior. Both incisions sever everything down to the bone.

2. *Raising the Flaps.*—The anterior flap is dissected up partly with the knife and partly with the left hand. It should contain

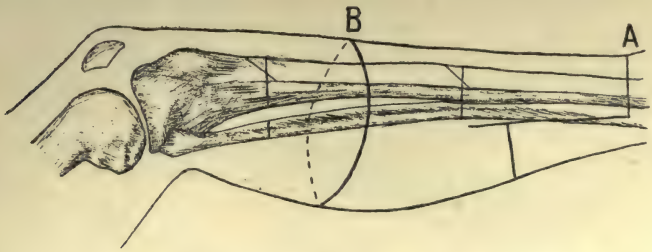


FIG. 54.—TEALE'S AND CIRCULAR AMPUTATIONS.
A, Teale's amputation. B, Circular amputation at the site of election.

all the tissues from off the front of the bone and interosseous membrane, care being taken not to injure the anterior tibial vessels. The posterior flap is then raised containing all the tissues from off the bones. Both flaps are retracted above the saw line.

3. *The Interosseous Membrane is cut and the Periosteum of the Bones divided with the knife.* The bones are divided with the saw in the manner already described.

The anterior tibial artery is found at the free margin of the anterior flap, between the tibialis anticus and the extensor communis digitorum, and behind the extensor proprius hallucis tendon. The posterior tibial artery is rather to the inner side of the posterior flap, between the flexor longus hallucis and the flexor longus digitorum. The peroneal artery is to the outer side of the posterior flap in front of the flexor longus hallucis.

The anterior flap is then folded on itself over the end of the bone and sutured in position.

(2) Amputation by a Long Posterior and a Short Anterior Flap

Having noted the circumference of the limb at the level of the future saw line, the U-shaped posterior flap is made so that in length and breadth it equals one-third of this measurement, *i.e.* it equals the diameter of the limb. The anterior flap is rounded and is one-third of the length of the posterior (Fig. 55, A).

1. *The Incisions.*—The knee is flexed and the leg (right) turned on its side. The inner part of the U is commenced from

above downwards, just below the level of the future saw-cut, immediately behind the inner border of the tibia, the lower part being curved outwards over the back of the leg. The limb is now turned on its inner side and the outer part of the U made in the same manner immediately posterior to the peroneal muscles, its lower part sweeping in to meet the termination of

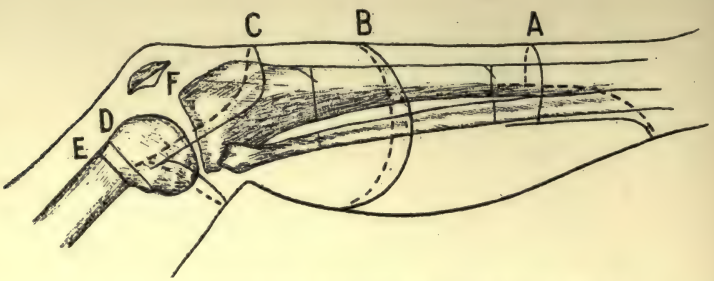


FIG. 55.—AMPUTATIONS THROUGH LOWER PART OF LEG.

A, Amputations through the middle of the tibia by a long posterior and short anterior flap. B, Amputation at the site of election by lateral flaps. C, Incision for the Stokes-Gritti amputation. D, Saw-line in Gritti's operation. E, in Stokes. F, Saw-line of patella.

the previous incision. In the left leg the outer incision is made first with the limb on its inner side. The anterior flap is made by bringing the knife in a slightly curved manner across the front of the leg. The incisions are deepened to free the skin, which is retracted to its full extent.

2. *Raising the Flaps.*—The knee being well bent is rotated so as to turn the calf towards the surgeon. The tendo-Achillis is picked up and divided at the level of the retracted skin. A deep, short, vertical incision is then made from above downwards at each margin of the posterior incision. Into these the thumb and forefinger of the left hand are thrust, and the soft tissues raised from the back of the bones and interosseous membrane. The tissues in the left hand are divided at their lower part, either from within outwards, or from without inwards, as preferred. The muscles in the anterior flap are divided straight down to the bone at the level of the retracted skin, and both flaps reflected to the level of the saw line.

3. *Division of the Bones.*—The interosseous membrane and the periosteum are divided and the bones cleared. Retractors are used to protect the soft tissues, while the bones are sawed through in the usual manner.

The posterior tibial nerve is dissected out.

Comment.—Teale's amputation produces a stump well covered by soft parts, but not capable of bearing any great amount of pressure, while the great length of the flap renders it liable to slough if the anterior tibial artery is wounded above its free edge ; it also necessitates a high division of the bones. For these reasons it is seldom performed in the living subject, though often met in the examination-room. The anterior flap must be kept the same width all the way down or it will not fit the posterior flap. The method by the large posterior flap, which is sometimes known as Hey's operation, produces an excellent covering for the ends of the bones. Almost equally good is the method by lateral flaps, with circular division of muscles, which is carried out in exactly the same way as is described in dealing with amputations at the site of election.

Amputation at the Site of Election

(1) Large External Flap (Farabeuf)

1. *The Incisions.*—The knee is bent and the leg turned on its inner side so as to expose the outer surface. The surgeon places

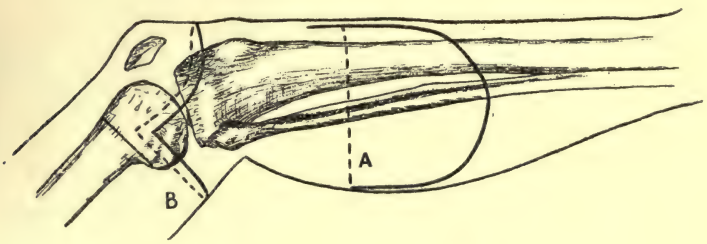


FIG. 56.—FARABEUF'S AND CARDEN'S AMPUTATIONS.
A, Farabeuf's amputation at the site of election. B, Carden's amputation through the condyles.

the forefinger of the left hand on the anterior border of the tibia (right leg) at the level of the future saw-cut, the thumb is placed on the middle of the posterior surface of the limb, one and a half inches lower down. The external flap is marked out by a U-shaped incision, starting in front and passing downwards along the anterior border of the tibia. It then sweeps across the outer aspect of the leg in a curved manner and ascends vertically to the thumb behind. The length of the flap must equal a little more than the diameter of the limb at the level of the future

saw-cut. In the case of the left leg the positions of the finger and thumb are reversed, and the incision commences behind.

The limb is turned outwards and the short inner flap marked out. This is done by drawing the knife transversely across the inner surface of the limb from the upper limit of the posterior incision to meet the anterior incision one and a half inches below its commencement.

The integuments only are divided and allowed to retract.

2. *Dissection of the Flaps.*—The external flap is dissected up first, the limb being again turned on its inner side.

The tibialis anticus muscle is separated from the outer surface of the tibia from above downwards, the left hand being used as a retractor. At the lower edge of the flap the muscles are cut obliquely to the level of the retracted skin. The flap contains all the tissues from off the bones and interosseous membrane. The greatest care must be taken not to injure the anterior tibial artery.

The incision marking out the inner flap is now deepened down to the bones, and the soft parts retracted to the level of the saw line.

3. *Sawing of the Bones.*—The flaps being well retracted, the interosseous membrane divided, the bones are cleared and sawn through with the usual precautions.

The anterior tibial artery is found at the free edge of the anterior flap. The posterior tibial and the peroneal are found close together at the free edge of the inner flap. The large muscular branches to the muscles of the calf will have to be secured and probably the nutrient artery to the tibia.

The edges of the wound are then united, the cicatrix being on the inner surface of the stump.

Danger.—If the external flap is dissected up too far the anterior tibial artery may be cut as it passes forwards through the interosseous membrane. The vitality of the flap depends on this vessel. It is a common mistake to cut the external flap too short.

(2) Lateral Flaps (*see* Fig. 55, B)

1. *The Incision.*—The surgeon places his thumb on the anterior border of the tibia at the level of the future saw-cut, and his forefinger on the mid point of the calf exactly opposite.

Looking over the limb he starts the incision behind and cuts

a rounded flap on the side of the limb furthest from him, the incision ending at his thumb. The length of the flap is three and a half inches. A similar flap is now cut on the side of the limb nearest him, starting in front and ending behind.

2. *Dissection of Flaps and Division of Muscles.*—The flaps consisting of integuments and fascia are dissected back. A little below the saw line the muscles are divided down to the bone with circular sweeps of the knife. The muscles on the posterior surface, or at all events the bellies of the gastrocnemius, should be cut a little longer than those on the anterior surface as they retract more. The muscles are then retracted to the level of the saw line.

3. *Sawing of the Bones.*—The interosseous membrane and the periosteum of the bones are divided.

The anterior and posterior tibials, the peroneal arteries, together with muscular branches, will need ligatures. Owing to the circular division of the muscles they will easily be found on the face of the stump.

When the edges of the wound are brought together, the resulting scar will lie antero-posteriorly on the face of the stump.

(3) Circular Method (*see* Fig. 54, B)

The circular division of the skin is made three and a half inches below the future saw line. The skin is reflected back from the inner aspect of the tibia and front of the leg; posteriorly the skin is not reflected but merely retracted.

The gastrocnemius is pinched up in the fingers and divided at the level of the retracted skin. The gastrocnemius is then reflected back with the skin on the back of the leg. The rest of the muscles are divided in a circular manner below the saw line. The whole of the soft parts are then strongly retracted to the desired height. The bones are sawn through as before. The cicatrix lies transversely across the end of the stump.

Comment.—In the first of these three methods the ends of the bones are covered with a thick layer of muscle, the scar is away on the inner side, and the stump is suitable for bearing a considerable amount of pressure. Such a stump would be required if an artificial limb was worn with the knee joint extended, the movements of the joint being made use of in walking. Treves says, "I believe this to be the best operation for this segment of the leg." The other two operations are excellent if the weight of the limb is to be borne in the kneeling position with the knee flexed, the terminal position of the scar being then no drawback.

The method by lateral flaps has this advantage, that where the tissues on one side are damaged, the flap on the opposite side can always be lengthened to compensate for the loss.

Disarticulations through the Knee Joint

In this amputation the line of section passes through the lowest limit of the knee joint, the knife passing between the head of the tibia and the semilunar cartilages. These cartilages together with the patella are retained in the stump, and help to form a substantial covering for the end of the condyles.

Anatomy.—The internal condyle of the femur is larger and more prominent than the outer. This fact has to be taken into consideration when fashioning the flaps. The line of the joint can easily be felt if the leg is slightly flexed on the thigh, the fingers sinking in below the edge of the condyle on each side of the ligamentum patellæ.

The synovial membrane of the joint passes up above the level of the patella for one inch. In about 80 per cent. of cases it communicates above this level with the large bursa underneath the extensor muscles.

The important ligaments outside the joint are the posterior and the two lateral ligaments and the ligamentum patellæ. With these ligaments are associated certain muscles which help to move the thigh after amputation at the knee.

Connected with the posterior ligament is the insertion of the semimembranosus; with the internal ligament is the semitendinosus and sartorius; with the external ligament is the biceps tendon, which, however, is not definitely attached to the ligament.

Inside the joint are the important crucial ligaments, the external passing in front of the internal.

Of the semilunar cartilages the external is the rounder, and the more firmly attached of the two. They have an important bearing on the future of the stump for they cap the femur, and through their attachment to the posterior, internal, and lateral ligaments, prevent the protrusion of the bone and the retraction of the muscles from the end of the stump.

At the level of the joint the popliteal artery lies vertically on the posterior ligament. The polpiteal vein lies behind the artery and the internal popliteal nerve lies on a plane still more posterior and to the inner side of the vein. The external popliteal nerve lies to the inner side of the tendon of the biceps. The inferior internal articular artery runs obliquely downwards from just below the internal condyle of the femur, and is of large size.

The inferior external articular artery is smaller and passes forwards above the head of the fibula.

Both these vessels lie between the bone and the lateral ligaments of the knee joint. Large sural arteries are given off to the gastrocnemius above the level of the joint.

The internal saphenous vein lies just behind the internal condyle in the superficial fascia.

The disadvantage of cutting a large anterior flap for this operation lies in the fact that the blood supply to the skin below the front of the knee largely comes from the recurrent branch of the anterior tibial. This vessel must be cut in dissecting back such a flap.

Instruments.—An amputating knife with a blade four to six inches long.

Position.—The patient lies on the back with the thigh projecting well beyond the foot of the table. The surgeon stands on the right of the limb operated upon. One assistant supports and manipulates the leg, another stands opposite the surgeon.

Methods.—The following methods are here described:

1. By lateral flaps (lateral hooded flaps, Stephen Smith).
2. By long anterior and short posterior flaps.

1. By Lateral Flaps, Stephen Smith's Operation (Fig 57, A)

1. *The Incisions.*—The limb being extended and rotated outwards in the case of the right leg, inwards in the case of the left, the surgeon places his thumb over the tubercle of the tibia and the forefinger on the middle of the posterior surface of the limb at the level of the knee joint. The knife is passed over the limb and the first incision commenced below the forefinger. It is carried down the back of the limb for three and a half inches, and then curves forwards over the surface of the limb furthest from the surgeon, to ascend on the anterior aspect to below the thumb. The second incision starts in front and passes in a similar manner across the surface of the leg nearest the surgeon to end by joining the previous incision behind. As the incisions are made the assistant rotates the limb steadily away from the surgeon. On account of the greater size of the internal condyle, the inner flap should be a trifle longer than the outer. The incisions involve the integuments and fascia only.

2. *Dissection of the Flaps.*—These are dissected back as skin flaps to the joint level. Above the tubercle of the tibia the ligamentum patellæ is divided and allowed to retract.

3. *Disarticulation.*—Just below the level of the joint all the muscles and tendons are divided in front and at the sides down to the head of the tibia, including the fascia lata, sartorius, gracilis, semitendinosus and biceps, the external and internal lateral ligaments. The knife is then entered between the semilunar cartilages and the head of the tibia, and the coronary ligaments severed. The cartilages are freed from the tibia.

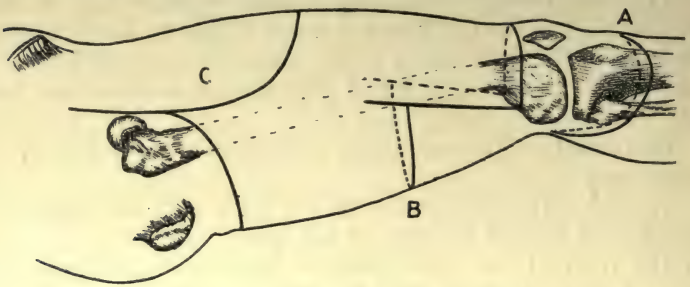


FIG. 57.—AMPUTATIONS THROUGH KNEE AND THIGH.

A, Stephen Smith's amputation through the knee. B, Teale's amputation through the thigh: note that the long flap does not pass straight down the limb as the base and the end of the flap must be the same size. C, Amputation through the hip joint by transfixion.

The tissues on the back of the joint are next divided with a transverse cut and the leg removed.

The popliteal artery and vein, the azygos and inferior articular branches, the superficial division of the anastomotica magna and the sural vessels must be caught. The internal and external popliteal nerves are cut short. The edges of the wound are united, the scar lying vertically on the posterior surface of the stump between the condyles. The wound is thus in an excellent position for drainage as the patient lies in bed.

2. By a long Anterior and short Posterior Flaps

1. *The Incisions.*—The incision for the anterior flap is commenced just below and behind the internal condyle (right limb), and is carried vertically down the limb for nearly five inches; it is then gradually brought across the front of the limb and passes up on the opposite side to a corresponding point below and behind the external condyle.

The posterior flap is made two-thirds the length of the anterior, and is marked out by drawing the knife transversely across the posterior aspect of the limb from one vertical incision to the other.

2. *Dissection of the Flaps.*—The anterior flap is dissected up as thickly as possible and contains the patella. The posterior flap consists of integuments and fascia only. The muscles are divided at the level of the joint.

3. *Disarticulation.*—This is performed as described in the last operation.

The scar is placed transversely on the posterior surface of the stump.

Comment.—The first of these two methods is much the better. The stump resulting after amputation by lateral flaps is well nourished, the flaps are easily procured and have little tendency to slough. In the second method, the long anterior flap is thin, and being separated from its natural blood supply, the recurrent branch of the anterior tibial, is in consequence very liable to slough. In neither case can the stump be relied upon to receive the full weight of the body in locomotion.

Amputations through the region of the Condyles

Anatomy.—The chief bony landmark in this region is the tubercle on the upper part of the internal condyle of the femur into which the tendinous part of the adductor magnus is inserted.

This is well above the level of the cartilaginous surfaces of the lower end of the femur. The epiphyseal line at the lower end of the femur passes transversely across the bone at the level of this tubercle. In young subjects, therefore, the saw-cut should pass above this level to prevent the formation of a conical stump from the continued growth of the bone. The epiphysis begins to ossify before birth, but does not join with the shaft till after the twentieth year. The medullary canal of the bone is not met with for a considerable distance above the tubercle. The only muscles attached to this region are the adductor magnus, the two heads of the gastrocnemius, and the plantaris.

In clearing the bone the lateral expansions of the vasti and crureus muscles are divided, allowing considerable retraction of the quadriceps extensor and patella.

The popliteal artery passes downwards and outwards to reach the middle of the popliteal surface of the femur. The vein lies behind the artery. The internal popliteal nerve lies posterior to, and some way to the outer side of the vein. The superior articular arteries run round the bone just above the condyles, the external being the larger of the two. The superficial and deep divisions of the anastomotica magna will be met with on the inner

aspect and the descending branch of the circumflex artery on the outer aspect of the limb.

Instruments.—The same as those used in disarticulating through the knee joint, with the addition of a saw and a pair of lion forceps.

Position.—The same as in disarticulating at the knee joint.

Methods.—The following methods are here described :—

1. Carden's operation.
2. Lister's modification of Carden's operation.
3. Gritti-Stoke's operation.

1. Carden's Operation (*see* Fig. 56, B)

1. *Incisions.*—The surgeon places his forefinger and thumb over the most prominent point on the condyles, the knee being slightly flexed. The anterior incision starts from the forefinger on the side of the limb furthest from the surgeon, and passes downwards and then forwards to sweep over the tubercle of the tibia, and ascend on the near side of the limb to the thumb. The incision divides the integuments only. The posterior incision is a transverse cut between the two horns of the anterior incision, the skin only being divided. In actual practice, where time is of great importance, the posterior incision may be made by transfixion, the knife cutting directly backwards, but this proceeding should not be followed by the student as the flap is apt to look ragged.

2. *Dissection of the Anterior Flap.*—This flap is dissected up as thickly as possible from the front of the patella till the upper margin of that bone is reached.

3. *Division of Muscles.*—The flaps are well retracted and the knee slightly bent. With circular sweeps of the knife all the soft parts are divided down to the bone. The muscles are well retracted and the periosteum divided opposite the adductor tubercle.

4. *Sawing the Bones.*—The saw must be applied perpendicularly to the shaft of the bone, but at right angles to the long axis of the limb (not femur).

The popliteal vessels are found close to the bone. In the posterior flap will be found the articular arteries, muscular branches, and branches from the anastomotica magna. Descending branches from the external circumflex artery may need securing in the outer part of the anterior flap.

2. Lister's Modification of Carden's Amputation

By this method a short posterior flap is formed and a larger covering for the ends of the bones obtained. The incisions are as follows :—

A U-shaped incision is made from side to side across the front of the limb at the level of the tubercle of the tibia as in Carden's operation. The two ends of this incision are prolonged by carrying the knife downwards and backwards at an angle of 45 degrees to the long axis of the limb.

The integuments are dissected back. The ham-string tendons are divided as they are exposed.

The rest of the operation is performed as described above.

3. The Stokes-Gritti Operation

Gritti first conceived the idea of capping the raw surface of the femur with the sawn patella, in the same way as, in Pirogoff's amputation, the lower ends of the bones are capped by the sawn os calcis. In Gritti's method an anterior rectangular flap reaching from the condyles to the lowest part of the tubercle of the tibia was made and dissected back, containing the patella. No posterior flap was made and the femur was sawn across at the same level as in Carden's amputation. The patella was sawn vertically and applied to the lower end of the femur. At this level the cross section of the condyles presents a much larger sawn surface than the patella. Owing to the retraction of the anterior flap the patella was drawn forward and lay over the anterior edge of the femur, if it was not drawn up altogether in front. Sir William Stokes modified this proceeding by cutting rounded flaps, starting from a higher level than those in Gritti's operation. He also made a posterior as well as an anterior flap. The femur was sawn through three-quarters of an inch above the adductor tubercle. The area of cross section at this level approaches more accurately that of the sawn section of the patella, while at the same time it is still below the level of the medullary canal of the femur. The higher section of the bone allows the apposition of the patella to the end of the bone to be more easily brought about, and there is less likelihood of its being drawn forwards by the retraction of the quadriceps. In Gritti's operation the section of the femur was trans-condylar ; in Stokes's it is supra condylar. The operation described usually bears the names of both surgeons.

Instruments and Position.—As in Carden's operation.

Operation.—1. *The Incisions.*—The anterior flap is marked out by the surgeon placing the forefinger and thumb of the left hand on the sides of the limb, the one being a little above and behind the external condyle, the other at a spot exactly opposite (see Fig. 55, C). The student should mark these points previously to starting the incisions, for when the limb is thick he will find it difficult and perhaps impossible to span the points with his hand. The knife is entered on the far side of the limb at the forefinger,

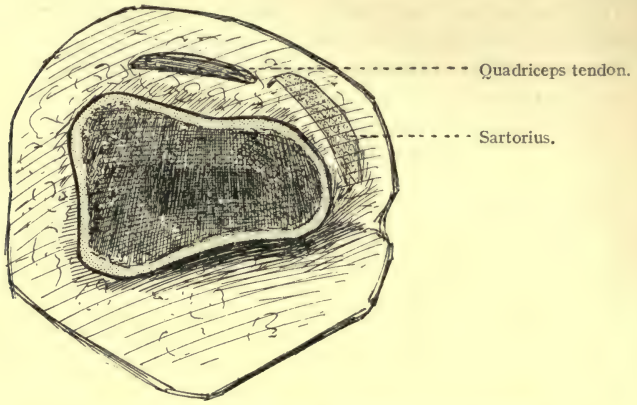


FIG. 58.—SECTION OF BONE IN GRITTI'S OPERATION.

and a U-shaped flap marked out reaching down to the tubercle of the tibia, the incision ending at the thumb. The posterior flap is half the length of the anterior. It is cut by passing the knife under the thigh and cutting in a curved manner from one side of the anterior incision to the other across the back of the limb.

2. *Dissection of Flaps and division of Muscles.*—A thick anterior flap is dissected up containing the patella and capsule of the knee joint. The posterior flap is dissected up containing only the integuments and fascia. The flaps are well retracted and the muscles divided down to the bone, a little below the saw line.

3. *Sawing the Bones.*—The muscles are retracted to three-quarters of an inch above the adductor tubercle, and the periosteum divided with a circular cut. The femur is then divided at this level.

The anterior flap is held back flat and the tissues round the patella divided to clear a line for the saw. The patella is held firmly and the articular surface removed with the saw. This,

on account of the mobility of the bone, is rather a difficult proceeding, and care must be taken to bruise the flap as little as possible.

The popliteal vessels are found to the inner side of the shaft of the femur, fewer branches need securing at this level than in

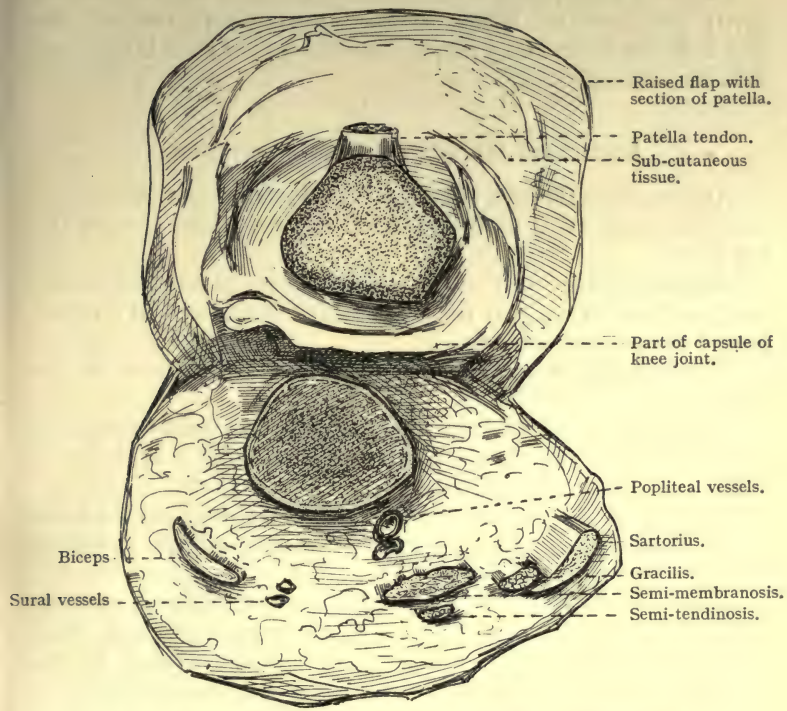


FIG. 59.—SECTION OF BONE IN STOKES' OPERATION.

Cf. Fig. 58. Both figs. were drawn from actual specimens at St. Mary's Hospital by Mr. W. H. Jones.

the last operation. The internal and external popliteal nerves are cut short. The raw surface of the patella is applied to the raw surface of the femur. The bones may be secured in apposition with silver wire or catgut sutures, pegs or screws. The edges of the flaps are united, the scar being on the posterior surface of the stump.

Comment.—An amputation through the region of the condyles is not such a simple procedure as disarticulation through the knee joint, but has great advantages over an amputation through the shaft of the femur at a higher level. The shock of the operation

increases as the trunk is approached; the lower the section, therefore, the better for the patient. The stumps at this level have not the same tendency to become conical that they have higher up. The insertions of the adductor muscles are not interfered with and the stump is more readily moved in consequence.

Carden's amputation is the easiest to perform, but the Stokes-Gritti produces the better stump. In Carden's method the flap is on the small side; ample covering for the bone is obtained in Lister's modification.

Amputation through the Shaft of the Femur

Amputations through the thigh include those above the supracondylar amputation of Stokes-Gritti and below the level of the hip joint.

Anatomy.—The shaft of the femur is pear-shaped on section; the broad end of the pear being anterior, the narrow end is represented by the linea aspera.

The medullary canal occupies the middle two-fourths of the shaft.

In the upper third of the thigh the bone is found nearest the outer surface of the limb; in the middle third it is central; in the lower third it is nearest the anterior surface.

The fascia which surrounds the limb is thinnest on the inner side, on the outer it is specially thickened by the ileo-tibial band.

All the muscles are attached to the shaft of the bone with the exception of the long head of the biceps, semi-tendinosus, semi-membranosus, gracilis, sartorius and rectus. Owing to the freedom of these muscles the tissues of the stump retract more on the inner and posterior aspects than elsewhere.

The femoral artery gradually comes to lie on the inner side of the shaft of the bone as it passes down the thigh. At the junction of the middle and lower thirds of the femur the vessel ends by becoming directly continuous with the popliteal by passing through the opening in the adductor magnus to lie behind the plane of the bone.

When amputating by antero-posterior flaps, the vessel lies in the anterior flap above the middle of the thigh, and in the posterior flap below that level, and care must be taken not to split the artery.

Below Scarpa's triangle the femoral vein lies behind and to the outer side of the artery. In Hunter's canal the internal saphenous nerve lies in front of the artery. The internal saphenous

vein lies in the superficial fascia on the inner side of the thigh, passing up to the saphenous opening.

The profunda artery lies among the adductor muscles close to the bone. At the apex of Scarpa's triangle the profunda vein, the adductor longus and the femoral vein lie between the profunda and the femoral arteries.

The anastomotica magna arises from the femoral in the lower part of Hunter's canal. On the outer side of the limb is the descending branch of the external circumflex artery. The great sciatic nerve, or its two great branches—the external and internal popliteal—are found under cover of the hamstrings, behind the adductor magnus muscle.

Methods.—The following are described here :—

1. Antero-posterior flaps by dissection.
2. Antero-posterior flaps by transfixion.
3. Circular method.
4. Teale's method.
5. Lateral flaps.

Instruments.—A large amputating knife with a blade about six inches long for the flap method with circular division of muscles, longer for the transfixion and circular methods.

Position.—The patient lies on the back with the thighs projecting well over the end of the table, the ankle of the sound limb is secured to the leg of the table. The surgeon stands, if possible, on the right of the limb operated upon ; with the left thigh he must sometimes stand on its left side. One assistant supports and manipulates the limb, while a second stands facing the surgeon.

1. Antero-Posterior Flaps by Dissection (Fig. 60, B)

1. *The Flaps.*—The surgeon places the forefinger and thumb of the left hand across the front of the limb at the level of the future saw-cut. The knife is entered on the far side below the index, and, passing down the thigh, sweeps squarely across the front and up on the near side to the thumb, marking out an anterior flap about four and a half inches long. The limb being raised by the assistant, the knife is passed underneath and a flap three and a half inches long is marked out in a similar manner on the posterior surface of the limb.

2. *Dissection of Flaps and division of Muscles.*—The anterior flap is rapidly raised and turned back. The posterior flap is dealt with similarly. In both cases only the integuments are raised.

The flaps being retracted the muscles are divided with circular

sweeps of the knife, the muscles on the posterior surface being cut at a lower level than those on the anterior.

3. *Sawing of the Bone.*—The muscles are well retracted and the periosteum of the bone divided with the knife. The saw is applied

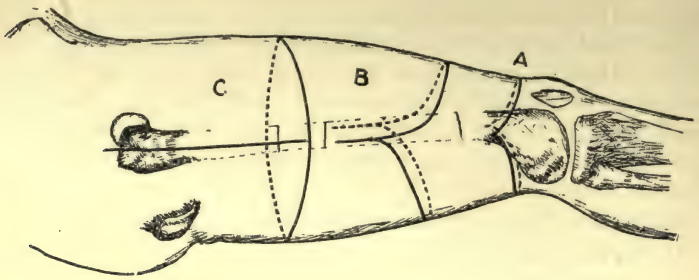


FIG. 60.—AMPUTATION THROUGH THE THIGH.

A, By Syme's modification of the circular method. B, Antero-posterior flaps. C, Esmarch's amputation through the hip joint.

and the bone severed. The prominent angle formed by the linea aspera may be rounded off.

The vessels are then secured, the nerves cut short, and the margins of the flaps brought together. The scar will subsequently lie on the posterior surface of the stump.

2. Antero-Posterior Flaps by Transfixion

The surgeon, marking out the base of his flaps with the thumb and forefinger, enters the knife behind the middle of the near side of the limb, and thrusting a little upwards, to allow the knife the more easily to pass in front of the bone, pushes it through the limb, the point emerging below the forefinger. With a sawing movement an anterior flap is then rapidly cut, four to four and a-half inches long, the knife coming out squarely at the end of the flap. The knife is then passed in a similar manner behind the bone, and a flap of equal length cut on the posterior aspect. In muscular limbs it is better to pass the knife well away from the back of the bone, so as only to cut the more superficial muscles. The skin should be retracted strongly as the flaps are being cut.

Both flaps are drawn back and the rest of the muscles divided with circular sweeps of the knife. The muscular tissue is then strongly retracted so that the bone section may be buried in muscular tissue. The periosteum is divided and the bone sawn through.

3. The Circular Method

1. *Skin Incision.*—The skin incision is made four and a half inches below the proposed bone section. The skin being drawn tightly upwards by the assistant, the surgeon passes the knife under, then across over the front of the limb, so that stooping well down the back of the knife is towards him, the heel resting against the thigh. Using the whole length of the edge, the knife is swept round the limb, the incision ending where it started. To facilitate this the assistant rotates the limb to meet the knife.

There is no necessity to complete the incision with one sweep of the knife, as the two ends can easily and rapidly be joined by a downward cut on the near side of the thigh.

The incision passes through the integuments only.

The cuff of skin is now rapidly reflected back for about four inches.

2. *Muscle Incision.*—The knife is now passed behind the limb and the hamstrings and gracilis muscle divided at a lower level than the rest. The muscles named being unattached to the femur, retract at once. The rest of the muscular tissue is now divided by a circular sweep, everything being severed down to the bone.

3. *Bone Section.*—The muscles are strongly retracted and with a third sweep of the knife the periosteum of the bone is divided at the saw line. The saw is now applied and the part removed. The vessels are easily found on the face of the stump.

The nerves are cut short. The margins of the skin flaps are united transversely. The scar is subsequently drawn inwards and backwards by the unequal retraction of the muscles.

Syme's Modification of the Circular Method

This only differs from the ordinary circular amputation in the method of making the skin incisions and reflecting the integument, and renders the latter process easier to accomplish (Fig. 60, A).

Two short antero-posterior flaps are marked out in place of making the circular incision. These small flaps are dissected up from off the deeper tissues as far as the base of each; the skin beyond the base of the flap is now turned back for about two inches in a cuff-like manner as in the ordinary circular amputation. The rest of the operation is performed as described.

4. Teale's Method (Fig. 57, B)

This is performed in exactly the same way as Teale's amputation of the leg, which has been fully described. The long anterior

flap is made equal in length and breadth to half the circumference of the limb at the level of the saw line. The same care must be taken here as in the leg to prevent the end of the flap being narrower than the base.

The posterior flap is a quarter the length of the anterior. Both flaps are rectangular and should be *marked* out.

5. Lateral Flaps

Amputation can be performed by this method, either by dissection or transfixion, in exactly the same way as was described in the case of antero-posterior flaps.

Each flap is made four to four and a half inches long, with well-rounded ends.

In transfixing, the knife is passed directly backwards on each side of the femur, the outer flap being cut first.

Comment.—Of these five methods just described, the first two by antero-posterior flaps, whether cut by dissection or transfixion, are practically the only ones used nowadays. The most accurate method is to cut the flaps by dissection, the difference in time is slight, and is fully compensated for by the results obtained. One flap can usually be lengthened to compensate for loss of tissue on the opposite side of the limb. In transfixing in the lower part of the thigh the femoral vessels are particularly liable to be split.

The circular method is easy to perform, but is not to be recommended because the unequal retraction tends to form a conical stump.

Teale's method is adapted for the lower part of the thigh, but is wasteful, demanding a higher division of the bone than is necessary. The anterior flap being thick is difficult to retain in a doubled-up position. The covering provided for the end of the bone is excellent, but the comparatively thin end of the shaft of the femur cannot bear weight.

The method by lateral flaps is particularly to be avoided. In the lower third of the thigh there is a great risk of splitting the vessels. Above the lower third there is still greater risk of the end of the femur projecting anteriorly between the flaps, owing to the falling back of the heavy flaps, which are unsupported by bone, and to the tilting forwards of the femur by the ilio-psoas muscle.

After-treatment.—Drainage tubes should be inserted at the angles of the wound for the first day or two, at the end of which time they should be removed. The limb should be firmly

bandaged in a large pad of wool to distribute the pressure and prevent oozing, it is fixed to a pillow in the elevated position, and sand-bags laid on each side and fixed to the pillow to prevent the painful twitchings of the muscles, which sometimes are most annoying to the patient. The stitches may be removed at the end of ten days, but if not irritating may be left in longer. Firm bandages must be applied to the stump, as the heavy flaps tend to fall away from each other if unsupported. Great care must be exercised not to soil the dressing with the evacuations of the patient.

Disarticulation through the Hip Joint

This operation ranks as one of the most serious in surgery, and is seldom performed. Bad accidents such as wheels passing over the region of the hip as in railway smashes, malignant growths, gunshot wounds, and some cases of very long-standing hip disease, where the disease has not been eradicated by excision of the joint, are the usual indications for the operation.

Anatomy.—The tip of the great trochanter is about on a level with the centre of the hip joint. The gluteal fold crosses the lower border of the gluteus maximus obliquely.

The muscles which pass from the trunk, wholly or partially, to the upper portion of the femur are the three glutei, the two gemelli, the two obturators, quadratus femoris, and the pyriformis posteriorly; the pectineus, adductors brevis, longus and magnus, internally; the ilio-psoas anteriorly.

The following muscles pass to the limb from the trunk, but are not attached to the upper end of the femur: the tensor fascia femoris, sartorius, rectus, gracilis, and the three hamstring muscles.

Portions of the two vasti and the crureus muscles extend high enough up the femur to be included in the region of the operation.

All these muscles are divided in this amputation.

The two large bursæ under the gluteus maximus, the one between the muscle and the great trochanter, the other between it and the upper part of the vastus externus, are capable of forming pockets in which fluids may collect.

The capsule of the joint, in front, where the Y-shaped ligament is situated, is far thicker than elsewhere.

The line of the femoral artery lies just in front of the inner part of the head of the femur, and therefore in front of the joint. The vessel is separated from the capsule by the psoas and the large bursa which lies under that muscle. The femoral vein lies

to the inner side of the artery at the base of Scarpa's triangle ; but at the apex the vein is behind the artery. The profunda femoris arises one and a half inches below Pouparts ligament. At first it lies external to the femoral, and then passes downwards and inwards behind that vessel.

The circumflex vessels arise from the profunda about half an inch from its origin, or two inches below Poupart ; the external runs outwards, the internal directly backwards, close to the small trochanter. The perforating vessels are found close to the shaft of the bone at intervals below the lower border of the pectineus muscle. To the inner side of the great trochanter posteriorly is the crucial anastomosis ; formed by the sciatic above, the first perforating artery below, the internal circumflex internally, and the transverse branch of the external circumflex externally.

Methods of Controlling the Hæmorrhage

1. *Jordon Lloyd's Method, by Elastic Compression.*—The limb is first emptied of blood by elevation and the application of Esmarch's bandages ; then the patient is rolled on to the sound side. A strip of stout rubber bandage is doubled and passed between the thighs, its centre lying between the tuber ischii and the anus. A common roller bandage is next laid lengthways over the external iliac artery. The two ends of the rubber bandage are now drawn strongly upwards and outwards, one in front and one behind the limb, to a point above the centre of the iliac crest on the affected side. The front part of the band passing across the bandage occludes the external iliac, and runs parallel to and above Poupart's ligament. The back part of the band passing across the great sciatic notch commands the branches of the internal iliac artery.

The ends of the bandage are held above the mid-point of the iliac crest by the hands of an assistant. If the surgeon is short-handed, instead of the ends being held, they may be secured to tapes which are then passed round the body, one in front and one behind, and tied above the iliac crest on the opposite side. A stout safety pin fixes the band to the roller bandage and prevents slipping. A loop of tape previously applied under the inner end of the rubber band and secured over the opposite iliac crest will be an additional safeguard to prevent the band slipping over the tuber ischii. An elastic band applied in this way effectually controls the whole blood supply and is well out of the way of the operator.

2. *Preliminary Ligature of the Vessels.*—This may be carried out through a separate incision, which needlessly complicates the operation, or through an incision marking out one of the flaps as in the anterior racket method.

3. *Wyeth's Pins.*—Two steel pins, or skewers, three-sixteenths of an inch in diameter and a foot long, are used. The limb is emptied of blood by elevation and Esmarch's bandages. The outer pin is entered a quarter of an inch below, and slightly to the inner side of the anterior superior spine of the ilium, and

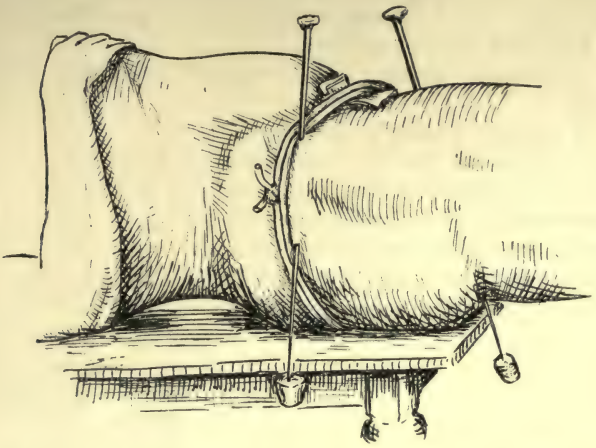


FIG. 61.—TOURNIQUET APPLIED WITH WYETH'S PINS.

made to traverse superficially for about three inches the muscles and fascia on the outer side of the hip, emerging behind on a level with the point of entrance. The inner pin is thrust backwards through the tendon of the adductor longus, half an inch from the pulis, to emerge one inch below the tuber ischii. The points of the pins are at once shielded with sterile corks to prevent injury to the hands of the operator. A compress of gauze two inches thick and four inches square, is laid over the vessels as they cross the brim of the pelvis. Solid rubber tubing half an inch in diameter is now wound round the limb five or six times above the pins, and tied in position. No vessels are endangered by these pins, and the blood supply is absolutely controlled.

4. *Compression with the Hands.*—This is rarely employed except in emergency, where the flaps are cut by transfixion.

5. *Macewen's Method.*—This method aims at controlling the blood flow by pressure on the abdominal aorta, and is applied

as follows: An assistant stands on a stool on the left side of the patient opposite the umbilicus. Passing the right foot forwards in front of the left he leans his weight on his right fist, which compresses the aorta just above the umbilicus. With his left hand he can ascertain how much pressure is needed to occlude the femoral pulsation on the sound side. Efficient control can in this way be obtained without undue fatigue to the assistant.

In this method there is a difficulty in avoiding pressure on such structures as the pancreas, duodenum, solar plexus, and intestines. The respiration is also decidedly embarrassed.

Methods.—The following methods will be described here:—

1. Anterior Racket method.
2. Combined circular and vertical incisions, Esmarch's Method.
3. Furneaux Jordon's method.
4. Antero-posterior flaps by dissection (Guthrie).
5. Antero-posterior flaps by transfixion (Liston).

Instruments.—An amputating knife with a blade about five to six inches long (for transfixion a blade ten inches long is needed), a Syme's amputating knife, scalpel, artery and dissecting forceps, scissors, retractors, needles, aneurysm needle, ligature and suture materials. In some of the methods described an amputating saw, to divide, and lion forceps to hold the bone, are required.

Position.—The patient lies slightly turned to the sound side, the pelvis resting on the end of the table. The sound leg is secured to the leg of the table, out of the way, and provision made to prevent the patient sliding off altogether. The surgeon stands on the outer side of the limb, right or left. One assistant attends to the tourniquet, if such is used, or helps to retract the flaps; a second assistant stands on the other side of the surgeon and manipulates the limb; a third stands on the opposite side of the patient ,facing and assisting him.

1. The Anterior Racket Method (by dissection)

At the present time this method is probably more often performed than any other; it has the great advantage that no tourniquet is needed and very little blood is lost to the patient.

1. *Ligature of Main Vessels.*—A three-inch incision is made precisely over the line of the femoral artery, commencing at the middle of Poupart's ligament. Both the artery and vein are exposed and a double ligature passed round each.

The ligatures should, if possible, be placed above the bifurcation of the artery, and should not be tied. The limb is then elevated and emptied of blood by Lister's method; on lowering the limb the ligatures are tied, those round the artery being tightened first. The vessels are divided between the ligatures.

2. *The Incisions.*—The lower part of the vertical incision is now continued round the inner side of the thigh, five inches below the pubis, and crossing the back and outer side of the thigh transversely, the knife ascends obliquely to join the lower part of the vertical incision. While making this incision the limb is rotated by the assistant so as to make the integuments meet the knife. The incisions are then deepened and the skin strongly retracted and freed for a short distance.

3. *The Outer Flap.*—The outer part of the incision is deepened first, and the following muscles are divided, the sartorius, rectus femoris, tensor fasciæ femoris, and the insertion of the gluteus maximus. The external circumflex artery may have to be secured at this stage if there has been a high division of the femoral artery. On adducting the thigh and rotating it inwards, the muscles attached to the great trochanter are severed.

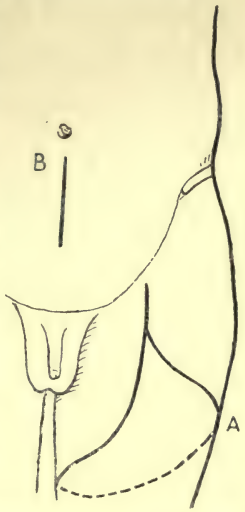


FIG. 62. — AMPUTATION THROUGH THE HIP.

A, Amputation at the hip by the anterior racket method (by dissection). B, Incision to expose the common and internal iliac vessels.

4. *The Inner Flap.*—The thigh is abducted and rotated outwards. The ilio-psoas tendon is divided and the adductor group of muscles cut, the internal circumflex vessel must be secured if not already controlled by the ligature. On retracting the muscles the whole of the front of the capsule is freely exposed.

5. *The Dislocation and Freeing of the Bone.*—The front of the joint is opened, the limb rotated outwards, the round ligament cut and the head turned out of the socket by extending the hip. The posterior part of the capsule with the tendon of the obturator internus are divided. The head of the bone is drawn forward, the knife is passed transversely behind the bone and made to cut outwards through the hamstrings and lower part of the adductor magnus muscle. Too much muscle should not be left in this posterior part of the flap.

Any vessels such as the obturator are secured on the face of the stump.

2. Combined Circular and Vertical Incisions (Esmarch's Method)
(*See* Fig. 60, C)

The operation falls naturally into two steps—

1. The circular amputation through the femur.
2. The enucleation of the upper end of the bone.

1. *The Circular Amputation through the Femur.*—The surgeon divides the skin all round the thigh by a circular incision made in the usual way, six inches below the tip of the great trochanter. The integuments are turned back rapidly for the distance of two inches. It is unnecessary to turn back more skin, as the femur being subsequently removed the muscles retract to their full extent. (In the original operation Esmarch divided skin and muscles straight down to the bone, five inches below the great trochanter.) The skin being retracted, all the muscles are divided down to the bone. The bone, without further clearing, is divided with the saw. The main vessels, femoral and profunda, and any others seen are at once secured with forceps.

2. *Enucleation of the Upper End of the Bone.*—The end of the divided bone is now seized with lion forceps held in the left hand of the surgeon, one blade being placed in the medullary canal, the other externally. The vertical incision is now made; starting from a point two inches above the tip of the great trochanter it passes down the outer side of the limb to join the circular incision. This incision is made down to the bone. The margins of the wound are retracted and the upper end of the bone cleared. A Syme's knife is useful here to clear the anterior, superior, and posterior borders of the great trochanter in this order, the stump being adducted and flexed.

The shaft of the bone is cleared rapidly in front and behind, care being taken that the femoral vessels are not injured.

The margins of the wound are further retracted and the stump still further adducted. The capsule of the joint is opened above, behind, and in front. The bone is then rotated outwards and the ligamentum teres cut. The head of the bone is now completely dislocated from the acetabulum. With his left hand the surgeon seizes the head of the femur, and, pulling strongly outwards, runs the knife along the inner surface of the bone, dividing the last muscular attachments. The bone is then free.

The main vessels, femoral and profunda, have already been caught during the first part of the operation. The branches of

the internal circumflex will be found on the inner side below the acetabulum. The transverse and descending branches of the external circumflex are found near the front at the outer side of the anterior flap. Branches of the sciatic artery will be found in the posterior flap.

The margins of the wound are united with large sutures and free drainage allowed on the outer side.

If time can be spared, the second part of this operation may be done sub-periosteally, a raspatory instead of a knife being used to separate all but a few of the tendons in the region of the linea aspera and great trochanter, which are too adherent to be detached otherwise than by the knife. This must not be done when the bone is the seat of malignant disease. Very little is gained by this step, and much time, a valuable adjunct to such a serious operation, is lost.

3. Furneaux Jordan's Method

"The principle of the operation may be thus described: First enucleate the bone, then cut through the limb at any desired spot—the middle of the thigh, or below, or even near the knee" (Furneaux Jordan).

In this the external vertical incision is made first and reaches to below the middle of the shaft of the femur. The upper end of the bone is freed from muscular attachments, the capsule of the joint opened, and the head dislocated. Next the shaft of the bone is cleared downwards for a considerable distance.

The head of the bone is pulled outwards, the knife is passed between the bone and the thigh, and then with a free sawing movement all the tissues on the inner side of the thigh are severed and the limb removed. No bone being left, the muscles quickly contract, and are easily covered with skin. The vessels are only divided in the last part of the operation, so little blood is lost. An enormous raw surface is left by this method.

4. Antero-Posterior Flaps by Dissection (Guthrie)

Here a knife with a blade about four inches long may be used.

1. *The Incisions.*—The anterior flap, which is about five inches long, is marked out as follows. The knife is entered just above the great trochanter, three or four inches below the anterior superior iliac spine, and passing in a U-shaped course down the outer side, across the front, and up the inner and back aspects of the thigh, ends just below the ischial tuberosity. The posterior flap is

about two-thirds the length of the anterior flap. It is cut by passing the knife in a curved manner, across the back of the thigh, uniting the ends of the anterior incision. The assistant raises the thigh to allow the posterior incision to be made.

2. *Raising the Anterior Flap and Ligature of Vessels.*—The skin being freed and retracted, the main vessels are secured on the front of the thigh and divided between two forceps, or a ligature may be applied. The three gluteal muscles are divided close to the bone, and all the muscles on the front and inner surface of the thigh are now cut through from below upwards.

3. *Dislocation of the Bone and the cutting of the Posterior Flap.*—With the anterior flap retracted the capsular ligament is freely incised and the ligamentum teres cut. The head of the bone is then dislocated from the acetabulum. Drawing the head forwards, the knife is passed behind it and made to cut its way out at the posterior skin incision. Too much muscle must not be left in the posterior flap or the integuments will not cover the wound.

5. Antero-posterior Flaps by Transfixion (Liston). (Fig. 57, C)

A knife equal to one and a half times the diameter of the thigh at the hip joint is required. The surgeon stands on the outer side of the right limb, between the thighs for the left limb. The anterior flap is to be cut U-shaped and not tailed off, its length is five inches. The posterior flap is shorter, being only four inches long. No tourniquet used to be applied when this operation was in vogue, the vessels being controlled by the hands of an assistant.

As rapidity is the great recommendation of this operation, the assistant who manipulates the limb has an important office to fulfil, the position of the limb changing in quick succession.

1. *The Anterior Flap.*—The thigh (right) is a little flexed and abducted. The knife is entered at a point midway between the anterior superior iliac spine and the tip of the great trochanter. It is thrust obliquely downwards and inwards, parallel to Poupart's ligament, to emerge on the inner side about one inch below and one inch in front of the tuber ischii, that is about three inches from the anus.

If correctly passed the knife should graze the head of the femur and open the capsule of the joint. Care must be taken that the knife does not split the vessels, enter the obturator foramen, hitch against the femur, wound the testicle and opposite thigh of the patient, or the fingers of the assistant.

With rapid sawing movements the knife is carried down close

to the bone for some way and then made to come out squarely at the end of the flap. The assistant who is compressing the vessels against the brim of the pelvis with his thumbs, thrusts his fingers under the flap behind the knife, and grasping the flap, controls the vessels before they are divided at its free end.

2. *Disarticulation.*—The flap is drawn up out of the way by the same assistant. The limb is straightened and the knee depressed. The anterior part of the capsule is opened. The thigh is rotated outwards, the ligamentum teres divided, and the head of the bone disarticulated. The thigh is then abducted and rotated inwards and the muscles about the great trochanter are cut.

3. *The Posterior Flap.*—The assistant lifts the whole thigh upwards and forwards, while the surgeon passing the knife behind the head of the bone, and cutting downwards and backwards, fashions the posterior flap. The hæmorrhage, chiefly coming from the gluteal and sciatic arteries in the posterior flap, is first attended to. The internal circumflex is found to the inner side of the acetabulum. The profunda femoris is divided about the middle, and the femoral at the free end, of the anterior flap.

Comment.—In all these methods the operation is greatly simplified in cases of old tubercular joint disease, when the head of the bone has been previously excised.

The various methods have been described in their order of merit, the anterior racket being much the best.

The combined circular and vertical incisions have decided advantages over the remainder, whether carried out by the method of Esmarch or Jordan. (It is well to state that in many text books the name of Furneaux-Jordan is wrongly applied to Esmarch's operation or its modifications.) If preferred the femur need not be sawn through after the circular incisions are made, the limb being manipulated by an assistant.

The advantages of the two methods are :

1. A tourniquet can be applied.

2. The muscles are divided transversely and the raw surface left is consequently small.

3. The sciatic and gluteal arteries are scarcely interfered with.

4. The position of the wound is far removed from sources of sepsis such as the urethra and anus.

5. The stump is good ; the ischial tuberosity, on which the weight is subsequently borne, is well covered.

In Esmarch's method the wound area is much smaller than in Jordan's. In the former the vessels are divided early, in the latter late. Esmarch's method is the best by which to carry out

the sub-periosteal method of clearing the bone. In Jordan's method the lower section of the muscles (sometimes near the knee) lessens the shock from the operation, but it must be remembered that there is a proportionately longer vertical incision on the outer side of the limb. Esmarch's method has the great advantage that the patient is rid of the limb after the circular amputation, and if necessary the enucleation of the upper end of the femur may be postponed to a future date.

After-treatment.—Measures must be taken during and immediately after the operation to prevent and lessen shock. Warmth, saline transfusions, and stimulation may all be resorted to.

Free drainage must be allowed for the oozing which takes place from the large raw surfaces. The stitches must be numerous and deeply inserted as the flaps are heavy and tend to fall apart. The stump should be supported on a pillow. Large dressings must be applied and fixed with a figure-of-eight bandage round the stump and pelvis.

The bowels should be confined for a few days for fear of soiling and disturbing the dressings. The urine may have to be drawn off.

CHAPTER V

Osteotomies and Excisions of Bones

OSTEOTOMY

General considerations.—Osteotomy is the division of bone; it is usually performed to rectify malformations due to rickets, mal-united fractures, necrosis, anchylosis, and genu valgum.

Instruments.—In addition to the ordinary instruments required in every operation some special instruments are used for the accurate division of bone, such as a saw, chisels, osteotomes, and a mallet.

The saw is the ordinary Adam's saw which was devised for the subcutaneous division of bones. The instrument has a short, blunt-pointed cutting edge with fine teeth set at the end of a slender shank, after the manner of the blade of a tenotome. The back of the blade is narrower than the teeth to prevent the blade locking. The handle is made according to various patterns to suit individual fancies.

The chisel is an ordinary carpenter's chisel, the blade and handle made in one piece of metal. The cutting edge is square and only bevelled on one side. The instrument is made of the best steel, but only the end is finely tempered. The end of the handle is made broad to receive the blows of the mallet.

The osteotome differs from the chisel only in the fact that the edge is bevelled on both sides equally. The blade is in consequence wedge shaped. Along the side of the blade a half-inch scale is marked so that the distance the blade has travelled through the bone can be ascertained at a glance.

Both the chisel and the osteotome are made in different sizes.

A small cut is made directly down to the bone in a position where the bone is superficial and where the osteotome can be made to cut away from the important vessels and nerves. Before withdrawing the knife the osteotome is slipped into the incision

until it lies against the bone. With a few sharp blows of the mallet the instrument is made to engage the bone.

In using the osteotome the instrument is firmly grasped in the left hand, which is steadied by resting the ulnar border against the limb of the patient.

If the osteotome be not held firmly the blade may slip and a blow from the mallet may drive it into the soft tissues, causing great damage. A good area of the hard outer shell of the bone should be cut before the blade is sunk deeply into the interior. When the blade is gripped by the bone it should be moved from side to side in the direction of its breadth only, and never in the direction of the long axis of the bone.

When the pressure becomes too great the instrument can be withdrawn and a finer one substituted. There is great difficulty when using small incisions in finding the original cleft in the bone if one instrument is not slid in along the other before withdrawal.

In comparing the use of the osteotome with the saw it may be said that in the hands of the very skilful the osteotome equals and may surpass the saw. The osteotome divides cleanly without the disadvantage of leaving portions of bone to act as foreign bodies in the depths of the wound. On the other hand, it crushes the bone to a certain extent as the thicker parts of the wedge enter, it is also a dangerous instrument in the hands of anyone who is unpractised in its use. The saw, on the other hand, is easy to use, and very accurate.

Osteotomy may be divided into three classes of operation—

1. Linear osteotomy.
2. Cuneiform osteotomy.
3. Osteotomy with resection.

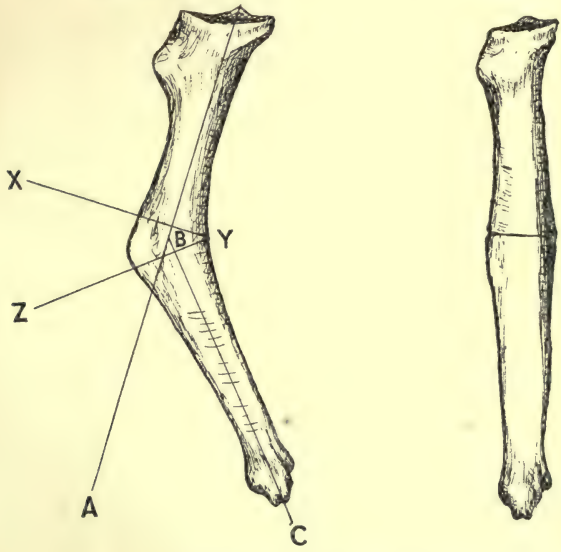
1. Linear Osteotomy.—This is the easiest to perform, and examples are found in the division of the femur or tibia. In slight cases this is all that is wanted, especially if the bone is as deep-seated as the upper end of the femur. The appositon of the ends of the bones must necessarily be inaccurate if the line of division is transverse to the long axis of the bone, but better apposition is obtained if the bone is divided obliquely. The plane of obliquity varying with the deformity.

2. Cuneiform Osteotomy.—This is the removal of a wedge-shaped piece of bone in such a way as accurately to rectify the deformity, while bringing at the same time the sawn surfaces of the bone in good apposition. It is specially suitable to superficial bones such as the tibia in rickety curvature.

The wedge of bone removed has its base at the prominence of the deformity; the size of the wedge is a matter for careful

FIG. 63.—TRANSVERSE LINEAR OSTEOTOMY.

FIG. 64.—OBLIQUE LINEAR OSTEOTOMY.



1 2

FIG. 65.—DEFORMED TIBIA.

1, Showing angle of deformity, A B C and the angle to be removed, X Y Z. 2, The same bone after the removal of the angle, X Y Z.

consideration. The angle of the wedge depends altogether on the angle of the deformity; the two angles should be made to equal one another as nearly as possible. This is best illustrated by an example. In Fig. 65, ABC is the angle of the deformity; XYZ is the angle of the wedge removed. When the wedge has been removed, if the angle XYZ has been made equal to the angle ABC, then the bones will be straight and the sawn surfaces will be in accurate apposition. Before the operation the angle of deformity should be carefully estimated. Another method of judging the size of the wedge is to make the cuts through the bone at right angles to the long axis of the bones above and below the deformity. The drawback of cuneiform osteotomy is that the bone is slightly shortened.

3. Osteotomy with Resection is of limited application; it is performed so as to bring bones to an equal length when from some reason, such as the destruction of the epiphyseal line, one bone has grown longer than another. The bone is cut down upon, the amount to be removed is estimated, and the bone drilled on either side of the part to be removed. The portion to be removed is sawn off, two saw-cuts being necessary. The ends of the bone are now wired together and the wound closed.

OSTEOTOMY OF THE FEMUR

1. For Ankylosis of the Hip-joint

Ankylosis of this joint may be remedied by two operations, either by division of the neck of the bone (Adams' operation) or by division of the shaft below the level of the trochanters (Gant's operation).

The object of both operations is to rectify the bad position of the femur.

(1) Adams' Operation—Division of the Neck of the Femur.

Instruments.—Ordinary, with the addition of a long tenotome and an Adams' saw. Some operators prefer to use a wide osteotome.

Position.—The patient lies on the table on the sound side. The surgeon stands on the outer side of the affected limb.

Operation.—An incision of about three-quarters of an inch to an inch in length is made, starting just above the tip of the great trochanter and passing upwards. A tentotome is then pushed

inwards and downwards till the neck of the bone is struck. The knife is then moved gently to produce a track for the insertion of the saw, which instrument should be inserted before withdrawing the tenotome.

If the saw is used as in the original operation by Adams, it is introduced in front of the neck of the bone, which is divided from before backwards. Four or five minutes' sawing should suffice to divide the bone.

With the osteotome, after the introduction of the instrument, the neck of the bone should be carefully felt for, and the instrument turned so that the blade lies at right angles to the axis of the neck. With the instrument held firmly in position a few blows of the mallet are sufficient to sever the neck.

When using either the saw or the osteotome care must be taken to make sure that the instrument is applied to the neck of the bone, and not to the broad mass forming the junction of the shaft with the neck.

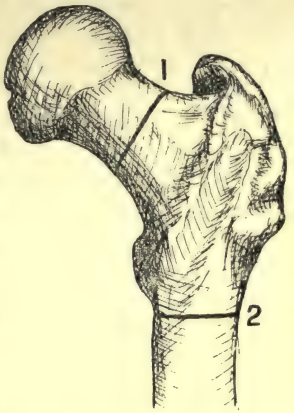


FIG. 66. — OSTEOTOMY FOR DEFORMITY OF THE UPPER END OF THE FEMUR.

1, Adams' operation. 2, Gant's operation.

(2) Gant's Operation—Division of the Shaft below the Trochanters

Position.—The patient lies on his back or on the sound side, whichever is the most suitable to the deformity, the limb being supported by sandbags. The surgeon stands as in the last operation.

Operation.—An incision is made running in the long axis of the femur for an inch or more, with its centre fully three inches below the tip of the great trochanter in the adult. The knife is passed down to the bone, and the osteotome is inserted before withdrawing the blade. A saw may be used in this operation if preferred. In any case the shaft of the bone should be completely divided, and not partially divided and then fractured, as accidents have occurred from splinters wounding the vessels during this procedure.

Often it is found that before the limb can be brought into a good position various muscles, contracted through long malposition, have to be divided. These are most commonly the muscles belonging to the adductor group.

The wounds can then be closed without drainage, and the limb put up at once in a suitable apparatus for fixing it in its new position, extension and a long splint being usually sufficient.

Comment.—Of the two operations that of division below the trochanters is the simpler, and is the one which is applicable to all forms of deformity. It has the further advantage that the wound does not communicate with the interior of the joint. The operation on the neck is only applicable to those cases in which the neck of the bone is not shortened and thickened.

2. Osteotomy for Genu Valgum

For the remedy of this condition three operations will be described, though the third (Ogston's) has been almost entirely replaced by the two preceding methods.

(1) Division of the shaft of the femur from the outer side.

(2) Division of the shaft of the femur from the inner side, just above the epiphyseal line (MacEwen's operation).

(3) Separation of the internal condyle of the femur (Ogston's operation).

(1) Osteotomy of the Shaft of the Femur from the outer side

Position.—The patient lies on the back with the knee slightly flexed over a sand-bag, the limb being slightly rotated inwards. The surgeon takes his stand between the legs or on the sound side of the patient. In using the osteotome it is recommended that the instrument should always be held so as to cut towards the surgeon whenever this is possible, so that the surgeon always takes his stand on the side furthest from the limb upon which he is operating. Operations on the upper end of the femur are an exception to this rule.

Operation.—An incision about one and a half inches long is made on the outer side of and at right angles to the long axis of the limb, two to three inches above the external condyle. This incision should be made down to the bone through the ilio-tibial band of the fascia lata and the fibres of the vastus externus and crureus muscles. Before withdrawing the knife the osteotome should be inserted parallel to the long axis of the bone. The cutting edge should then be turned at right angles to the long axis of the bone and placed firmly against the bone. The instrument is driven through the dense outer shell by blows of the mallet. The bone is here found to be denser on the outer than on the inner side, so that when two-thirds of the bone have been divided the surgeon can, without much force or difficulty,

fracture the remaining portion of the shaft. This, however, should not be attempted before it is certain that two-thirds of the bone have been severed.

Advantages.—The advantages of the operation are that it is extremely simple. There are no blood vessels, synovial membrane, or epiphyseal lines in the near vicinity, and the bone is divided at a much narrower part than in MacEwen's operation to be next described. The periosteum and bone on the inner side of the femur are left untouched, and keep the ends of the bone in good position.

(2) Osteotomy of the Shaft of the Femur from the inner side, just above the Epiphyseal Line

Position.—The patient lies on his back with the leg and thigh slightly flexed, abducted and rotated outwards, the limb being supported on sand bags. The surgeon stands on the outer side of the affected limb.

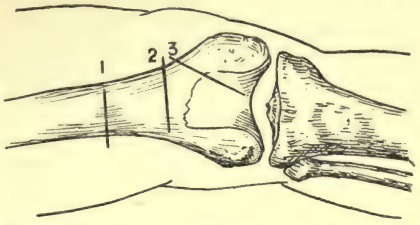


FIG. 67.—OSTEOTOMY OF THE KNEE.

1, Osteotomy from the outer side. 2, Osteotomy from the inner side. 3, Separation of the internal condyle.

Operation.—A sharp-pointed knife is entered at a point where the two following lines meet—one drawn transversely, a finger's breadth above the upper edge of the internal condyle, which should be carefully made out, and one drawn longitudinally half an inch in front of the tendon of the adductor magnus.

A longitudinal incision right down to the bone is made, long enough to admit the largest osteotome. Before withdrawing the knife the osteotome is passed into the wound. The knife is then withdrawn and the cutting edge of the osteotome turned transversely to the long axis of the bone. The direction of the instrument is of importance when cutting the bone. First the postero-internal portion of the bone is divided, the instrument pointing forwards and outwards; next the inner border of the bone is severed, the instrument pointing outwards; lastly, the instrument is directed from before backwards and slightly outwards towards the postero-external portion of the femur. If the bone is sclerosed or shows a tendency to grip the instrument, a finer one may be slipped in place along the first, which is then removed. With a small wound there is a difficulty in finding

the original incision in the bone if this precaution is not taken. A third instrument, finer than the second, is sometimes needed.

Experience teaches the surgeon to tell by sound or touch when he has reached the compact layer on the outer aspect of the bone. If it is thought wise to cut through this, the osteotome should be held very firmly to prevent any tendency it may have to pass suddenly into the soft tissues beyond. It is better to snap this layer than to cut it. When sufficient bone has been divided an aseptic swab is laid over the wound and held in position by the hand of the surgeon, which firmly grasps the limb at this level, this hand being used as a fulcrum. With the other hand he grasps the limb lower down and snaps the bone which has remained uncut.

The wound is closed with sutures, and the limb put up at once in plaster of Paris. The plaster of Paris case should be kept on for six weeks. The proof of the success of the operation lies in the fact that the two internal malleoli can be made to touch one another when the knees are fully extended and the patellæ directed forwards.

Comment.—The wound may be made transversely and not longitudinally if so desired. The incision described is above the superior internal articular artery, and in front of the anastomotica magna, so that little or no bleeding takes place. Although the synovial pouch reaches as high up as the incision, it is not in the way, as it tapers to a point opposite the centre of the front of the bone at this level and is separated from the bone by a small amount of fat.

It should be remembered that at this level the bone is much thicker at the outer than at the inner border, so that the osteotome should be directed well backwards before being laid aside (Fig. 58).

The site of correction is situated nearer the site of deformity than in the last operation. The osseous surfaces are broad and are easily kept in apposition. The bone is probably completely severed, for the outer part which is not cut by the osteotome is fractured, and then the fracture line is made to gape as the deformity is rectified.

(3) Separation of the Internal Condyle (Ogston's Operation) (Fig. 67, 3)

Position.—The patient lies on the back with the limb flexed over a sandbag. The surgeon stands between the legs in operating on the right limb, and to the left of the patient if operating on the left.

Operation.—A long, thin-bladed knife or tenotome is inserted one inch above the upper border of the articular surface of the femur in the middle of the inner aspect of the thigh. The knife cuts down to the bone, and is then thrust downwards and forwards into the joint in front of the bone. An Adams' saw is passed along the track of the knife before the latter is withdrawn, and the point felt under the skin. (It will be remembered that in this deformity the patella is dislocated some way to the outer side). The bone is now sawn from before backwards; the saw is withdrawn, however, before the bone is completely divided. If now a swab be held firmly over the incision with one hand and the limb, grasped lower down with the other hand, be forced inwards, the internal condyle will slip upwards upon the sawn surface of the femur.

Comment.—This procedure has been almost entirely superseded by the two preceding operations. The free opening of the joint with the serious results entailed should sepsis occur, the amount of stiffness which ensues even in favourable cases, and the difficulty in controlling the fragment, are all grave disadvantages. It is inapplicable in a young subject, as the saw traverses the epiphyseal line.

OSTEOTOMY OF THE TIBIA

This operation is called for to correct deformities due to rickets, syphilis, osteomalacia, and badly united fractures.

The bone may be bent in an antero-posterior or a lateral direction, or the two curves may be combined. In rickety bones there is usually a buttress of new bone found in the concavity of the curve so that the cross-section is increased at this point. The difficulty of producing a good result depends largely on whether the bone is bent only in one direction or in two. In children early splint pressure should be used to reduce the deformity, and if the splints are made to project beyond the feet so as to prevent walking, they will at all events ensure that the condition becomes no worse. Rickety children, being as a rule fat and flabby, should not be operated on for this deformity before the age of seven years, for the weight of the heavy child acting on the soft bones will inevitably reproduce the deformity.

The superficial position of the tibia admirably suits it for either linear or cuneiform osteotomy. In simple cases linear osteotomy is quite sufficient, the section of the bone being either transverse or oblique. In extreme cases cuneiform osteotomy

will be needed and probably more than one operation required before the limb is straight.

Linear Osteotomy

Position.—The patient lies on the back with the limb supported by a sand bag. The surgeon stands on the side to be operated on and the assistant opposite him.

Operation.—A narrow-bladed knife is entered on the flat at the anterior border of the bone opposite the most prominent part of the curve, and is pushed under the skin across the shin to the inner border of the tibia. The knife is then turned towards the bone, which is firmly cut open to divide the periosteum. The knife is then withdrawn and an Adams' saw inserted along the track thus made. If preferred, an open incision can be made across the shin and the saw applied under guidance of the eye. The bone is then sawn nearly across either transversely or obliquely, the depth to which the saw has sunk being carefully noted. The wound is next protected with a swab and the leg grasped with one hand while with the other the ankle is seized and the bone snapped across, the fibula at the same time sustaining, in young people, a green-stick fracture. The wound is stitched up and the limb put up straight, with firm pressure over the area of the wound (see Figs. 63, 64).

Cuneiform Osteotomy

Operation.—A longitudinal incision is made along the most prominent part of the curve just external to the sharp anterior border of the bone. In length it should extend a little further than the base of the wedge to be removed. The bone is exposed and the periosteum divided transversely on the inner and outer aspects of the bone. The periosteum is then stripped back with an elevator. It is as well to mark out on the bone the size of the base of the wedge to be removed. The operation is best carried out with the saw, but if a chisel is used, no attempt should be made to remove the piece marked out in one large wedge. It is removed in small pieces in the same way as a log of wood is cut through with an axe. A notch is cut and then enlarged and deepened first on one side and then on the other. In using the chisel the bevelled edge should always be kept towards the piece of bone to be removed.

When the marks previously made and the hard posterior surface of the bone have been reached, the bone is fractured as

in the last operation. If the deformity is not quite rectified on apposing the cut surfaces of the bone, a little more can be taken away. The bone is now laid in good position, the flaps of periosteum sutured with catgut, and the edges of the wound approximated with stitches.

The hæmorrhage is controlled by firm pressure; in a high section of the bone the large medullary artery which runs down-

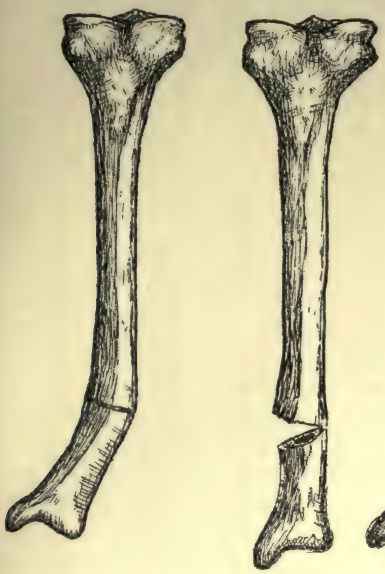


FIG. 68.—TRANSVERSE LINEAR OSTEOTOMY.

FIG. 69.—OBLIQUE LINEAR OSTEOTOMY.

wards may give rise to considerable bleeding during division of the bone.

After-treatment.—The leg is put up in splints in a good position and need not be looked at again for three weeks. The stitches are removed and the limb can be put up in plaster and left till union is quite firm.

Osteotomy for Extreme Cases of Talipes Equino Varus

This consists in the removal of a wedge-shaped piece of bone, composed of variable portions of the bones of the tarsus, in order to rectify an extreme and intractable amount of deformity. The operation as described is performed usually on adults whose condition has been more or less neglected in their infancy. In children, when the bones are soft, a very modified procedure

can be followed, combined with extensive tenotomy. In infancy, operations much less severe should suffice.

Instruments.—Ordinary, soft-metal retractors, narrow saw, lion forceps. Chisels may be used if preferred to the saw.

Operation.—The limb having been rendered evascular, an oval portion of skin is removed from the outer border of the foot, the long axis of the oval being in the long axis of the foot. The portion removed should include the greatly thickened cuticle, with the subjacent bursa, on which the patient is accustomed to walk. On the inner side of the foot an incision is made at right angles to the long axis of the foot, extending from the dorsum to the sole. It corresponds in position to the scaphoid bone. This incision generally coincides with the transverse crease found on the inner side of the deformed foot.

With a strong periosteum elevator the structures on the dorsum of the foot are raised off the bones, the surgeon working from without inwards. When this has been completed, a soft metal spatula is inserted and the tissues lifted off the bones, while a thin-bladed saw is inserted into the outer wound and made to protrude from the inner. A wedge-shaped portion of the tarsus is now removed, the base of the wedge being on the outer side of the foot, the apex corresponding to the scaphoid. Care should be taken when the blade of the instrument is nearing the plantar tissues. The wedge is now seized with lion forceps and freed by the scissors or the knife from the tissues that still hold it in position. The tourniquet being removed, hæmorrhage can now be dealt with. The gaping wound is flushed out with sterile salt solution to remove the debris. The sawn surfaces are brought together and may be retained in position with buried sutures if desired. A drainage tube is put in on either side, and the wound closed. The foot is put up on a posterior splint with a foot-piece, and later on enclosed in a plaster of Paris case, which should be worn from three to six months. Union should be firm in six to eight weeks.

Open incision for Talipes Equino Varus (Phelps' Operation)

This consists in making an incision down to the bone irrespective of ligaments and tendons. The foot is then wrenched into position, the wound gaping widely; the new position is maintained while the wound is allowed to heal by granulation.

Operation.—With the foot lying on its outer side an incision is made starting from a point mid-way between the tip of the internal malleolus and the tubercle of the scaphoid, and extending

outwards across the inner third or half of the sole. The following structures are severed, the branches of the internal saphenous and musculo-cutaneous nerves, the inner portion of the plantar fascia, the abductor hallucis, the tendons of the tibialis anticus and posticus and flexor longus hallucis muscles, and the calcaneo-scaphoid ligaments. If necessary, the internal lateral ligament of the ankle joint is divided; if possible the internal plantar vessels and nerve are spared. Force is then used to over-correct the position of the foot, and in doing this some of the deeper ligaments are ruptured. The tendo Achillis is divided with a tenotome if necessary. After the bleeding has been arrested the wound is plugged and allowed to granulate slowly from the bottom. The foot is put up in the over-corrected position, and maintained in this attitude with splints or suitable apparatus. When the wound has healed the foot is placed in plaster of Paris, and has to be kept under observation for one to two years.

Comments.—This operation is only called for in inveterate cases, and its advantage over the foregoing operation is very doubtful.

It has the advantage of not producing any shortening, but the scar is liable to contract and reproduce the deformity; a painful scar sometimes results; healing is a tedious process.

WIRING OF BONES

Wiring of the Patella

The special indications for this operation are: In old-standing cases, where the fragments are widely separated and the patient's life an active one in which the condition of the limb becomes a serious hindrance; in recent injuries, where the fracture is compound already, or where there is some special reason for the patient to be up and about in a short time. Any marked disease, such as alcoholism, obesity, or even old age, is an absolute contra-indication to the proceeding. In recent cases from four to ten days should be allowed to elapse before the operation is undertaken so as to allow the œdema to subside. Great care must be taken to be sure that the region is sterile.

Instruments.—Ordinary, with a saw, bradawl or drill, thick silver wire, and wire cutter.

Position.—The patient lies on the back with the leg extended. The surgeon stands on the outside of the limb, with the assistant opposite.

Operation.—A U-shaped incision is made with the convexity downwards. The flap is dissected up, and the patella fully exposed. In the recent cases the clot is cleared from the joint and ends of the bone ; in the old-standing cases a thin layer will have to be sawn off each fragment to produce a raw bony surface. The surgeon then proceeds to drill the fragments; on the right side he begins with the lower fragment, on the left with the upper one. Either one central wire is put in or two wires side by side. With a drill or an awl a hole is made starting about half an inch from the fracture and reaching the fractured or sawn surface close to the cartilage. Before withdrawing the awl the other fragment should, if possible, be brought into apposition and the awl made to mark the corresponding point on the opposite fragment. The awl is now withdrawn and the opposite fragment is drilled from the fractured surface where the mark was made towards the anterior aspect, the awl emerging half an inch from the rawed surface. If two wires are inserted the same procedure will be repeated. The silver wire is now introduced into the drill holes, the fragments brought together, and the wire twisted up; the direction and number of twists should be noted in case the wire needs removal subsequently. The wire is then cut short and hammered down on the front of the patella. In old standing-cases, where there has been much separation of the two fragments there will be difficulty in bringing the two pieces together, and some cutting of the quadriceps tendon will have to be resorted to. The wound is now closed, and the limb put up on a posterior splint.

FIG. 70.—METHOD OF INSERTING WIRES FOR UNITING A FRACTURED PATELLA. (*Allingham.*)

Results.—These are best in the recent cases where the fragments have not had time to atrophy, where no paring of the fragments is required, and where they are not bound down to the condyles by cicatricial tissue as is often found in old-standing cases. Should sepsis occur, osseous ankylosis is the best that can be hoped for. Statistics show that the result is satisfactory in about 94 per cent. of cases.

Wiring for Fractures of the Olecranon

This is a proceeding which is very similar to wiring the patella, and is undertaken for similar reasons.

A curved incision is made on the back of the limb to expose

the fracture. In old-standing cases, the upper fragment is freed so as to allow of its being pulled down, and the bony surfaces are freshened if need be with the saw or chisel. The fragments are drilled in exactly the same way as was described in dealing with the patella, and silver wire used to approximate the fragments; the ends are twisted together and hammered down. If there is difficulty in getting the fragments in apposition the triceps muscle may be partially divided. The limb is put up in the extended position with an anterior splint, and flexion in old-standing cases only brought about gradually.

Arthrotomy of the Knee Joint for Loose Semilunar Cartilages

The semilunar cartilage which is commonly at fault is the inner one, but occasionally the outer cartilage gives rise to the trouble. Operation is indicated if the affection is uncontrolled by the usual treatment with a knee cap or other apparatus, and causes such discomfort as to make life a burden, or to incapacitate the individual for his profession.

In carrying out this operation the very strictest aseptic precautions must be followed.

Position.—The patient lies on the back with the knee slightly bent over a sandbag, the limb being rotated outwards or inwards, according as the inner or outer cartilage is at fault. The surgeon stands on the outer side of the limb, the assistant stands opposite him.

Operation.—This will be described as if the internal cartilage was at fault. A curved or oblique incision, about three inches long, is made midway between the inner border of the patella and the internal condyle of the knee, the mid point being over the site of the cartilage. If desired the incision may be made transversely over the site of the cartilage. In these incisions care must be exercised not to damage the internal lateral ligament of the joint.

The synovial membrane is exposed and all bleeding arrested; the joint is then opened, and again all bleeding points are at once secured. The cartilage in cases which require operation is often found to be torn as well as loose. The cartilage is seized with toothed forceps and dissected away with a tenotome, as much as can be reached is removed; it is only in exceptional cases that the posterior portion can be got away, but this does not seem to matter as the posterior portion does not cause the locking of the joint. The synovial membrane is sewn up with fine

catgut sutures and the wound closed. The limb is put up on a posterior splint in a slightly flexed position, the splint should be kept on for at least ten days. No walking should be allowed for three or four weeks. The slight amount of stiffness which is experienced after this operation wears off after the patient gets about and uses the joint.

The operation on the external cartilage is an exactly similar proceeding on the outer side of the joint.

EXCISIONS OF BONES

Excisions or resection of bones may be complete or partial. In the former case the bone is all taken away, in the latter case only a part is removed, and this portion may be replaced later, this being known as temporary or osteo-plastic resection. This last is usually performed to enable the surgeon the better to gain access to the structures beneath, as in operations on the brain or pleura, or in cases of polypi situated at the back of the naso-pharynx.

The operation may be called for on account of new formations of a malignant character, tubercular disease, acute or chronic necrosis, some congenital deformities, such as club foot, or, as already indicated, the better to gain access to the deeper structures.

Instruments.—The instruments required are practically the same as those needed for the resection of joints.

Bistouries, sharp and probe-pointed ; there should be a knife with a strong blade and stout handle, called a resection knife ; dissecting, artery, bone, sequestrum, and lion forceps ; periosteal elevator, probe, director, retractors, scissors, osteotomes, chisels, gouges, mallet, and saws of different shapes according to the operation (see lists of instruments).

EXCISION OF THE UPPER JAW

This operation is called for usually for the removal of malignant growths involving the superior maxilla, whether of a sarcomatous or epithelial nature. Although the operation is usually looked upon as a complete excision, the entire bone is not as a rule removed, the frontal process remaining behind. It should be remembered that the superior maxilla is a thin shell-like bone, hollowed out by the antrum of Highmore, and when

infiltrated with malignant disease it is of a very friable nature, and has often to be taken away in pieces.

Instruments.—The special instruments required in addition to the ordinary ones are a gag, key-hole or fine saw with no back-piece to it (Gigli's wire saw may be used with advantage), lion and bone forceps, tracheotomy tube, sponge holders, and dental forceps.

Position.—The patient should lie on the back with the head dependent over the end of the table, so that the vertex looks towards the ground; blood then collects in and escapes from the nose without entering the respiratory passages. This position need not be adopted if a laryngotomy is performed. The surgeon stands on the right of the patient, whichever side is being operated on. The assistant stands opposite him.

Preliminaries.—There are two preliminaries which the surgeon may or may not decide to carry out. The one is a preliminary laryngotomy with subsequent plugging of the pharynx to prevent fluids entering the respiratory passages. With a laryngeal tube in position the operation is much easier. The other is a preliminary ligature of the external carotid on account of the extreme vascularity of the face, this makes the operation much cleaner and clearer; but as a rule there is no difficulty in arresting the hæmorrhage by ordinary means during the operation.

The operation can be divided into three stages.

(1) The incision and dissection of the flap.

(2) The division of the bony connections.

(3) The removal of the upper jaw.

Stage 1. *The Incision and Dissection of the Flap.*—The knife is entered below and a little internal to the inner canthus of the eye on the affected side, and made to cut downwards and slightly outwards to the ala of the nose, round which it skirts to reach the middle line. From here the knife completely divides the upper lip. A second incision is made from the same starting point and passes along the lower margin of the orbit on to the malar bone. The knife is made to divide everything down to the bone. The only muscles divided are the levator alæ nasi and the orbicular muscles of the orbit and mouth. No large arteries are divided, only the small branches of the facial, such as the angular artery and vein, lateral nasal, superior coronary, and its twigs to the septum of the nose. The flap thus marked out is rapidly dissected back from off the superior maxilla, the infra-orbital vessels and nerve being at the same time divided. The assistant turns the flap back upon itself and controls the bleeding by pressure till forceps can be applied. The orbital periosteum

is divided along the inferior margin of the orbit and detached from the floor of the orbit to expose the outer extremity of the spheno-maxillary fissure.

Stage 2. The Division of the Bony Connections.—The central incisor tooth is now extracted from the affected side. The muco-periosteum of the hard palate is divided by an incision just to one side of the middle line; the knife is then made to cut outwards along the junctions of the hard and soft palates. The ala of the nose is next separated from the anterior border of the maxilla. The saw is first applied to the vacant tooth socket and the alveolar margin and hard palate divided. Next it is applied to the frontal process of the superior maxilla through the nose, the eye-ball being protected by a broad spatula. Lastly the malar bone is divided so as to open into the outer extremity of the spheno-maxillary fissure, the orbital periosteum and eyeball being protected as before. The saw is now laid aside and the bone forceps used to complete the division of the bony connections, the forceps always being applied so that the bevelled surface is towards the bone to be removed. The bone forceps are applied to the malar bone, frontal process, and alveolar margin, in that order, *i.e.* in the reverse order to the saw. Without removing the forceps after the last cut they are used as a lever, the sound alveolar margin forming the fulcrum and by gentle rocking movements the bone is loosened from its deeper connections. The pterygoid processes are fractured close to their origin, and the lateral mass of the ethmoid gives way at the junction of the floor with the inner wall of the orbit.

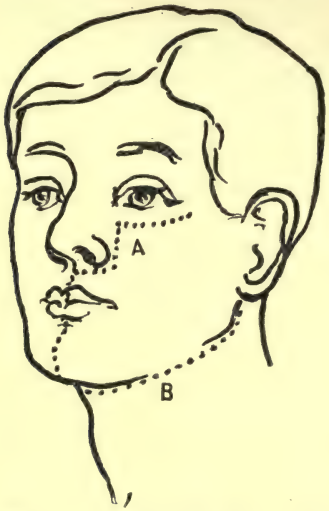


FIG. 71.—INCISIONS FOR JAWS.

A, Removal of the upper jaw. B, Removal of the lower jaw.

Stage 3. The Removal of the Upper Jaw.—Still retaining the bone forceps in position, the lion forceps are applied, one blade on the hard palate, the other on the orbital surface, and the bone levered and twisted out of its bed. The bone often breaks up at this stage and is removed in pieces. Bleeding is usually free in the depths of the wound from the terminal branches of the

internal maxillary artery, such as the alveolar, pterygo-palatine, descending palatine, and spheno-palatine arteries.

The hæmorrhage is stayed by sponge pressure till forceps can be applied or the cautery used. The depths of the wound are now carefully examined to make sure no disease remains. Any suspicious tissue is removed, shreds of tissue cut off and ligatures applied to the vessels. The wound is then firmly plugged with gauze and the flap replaced and accurately stitched in position; the angling of the incision enables this to be accurately accomplished.

After-treatment.—The plug is left *in situ* for the first twenty-four hours and is then removed through the mouth, the patient being encouraged to irrigate the mouth with a solution of warm potassium permanganate solution at frequent intervals. The sooner the patient is sitting up the better. After the plug is removed the patient may try to feed himself by means of a tube passed well back into the pharynx. If the soft palate has not been injured he soon accustoms himself to swallow easily.

Comment.—It is most important that the periosteum of the orbit should be maintained intact if not invaded by disease, as it serves to prevent sinking of the eye-ball, now no longer supported by bone. The nasal duct is cut across and the portion of the bone removed includes parts of the ethmoid, malar, palate, pterygoid processes and inferior tubinal bones. The resulting scar is hardly noticeable as it follows closely the natural lines of the face. If wished, the malar bone can be divided by a Gigli or chain saw passed by means of a needle or probe through the outer extremity of the spheno-maxillary fissure; the same instrument may be used to divide the bone between the nose and the orbit.

Later on a dentist's plate can be fitted, which serves to support the teeth and pad out and prevent the falling in of the cheek; it also acts as an obturator to shut off the nasal cavity from the mouth.

Partial Excision of the Upper Jaw

This operation should not be performed for malignant disease, as the risk of recurrence is too great, but partial excisions are performed for the removal of Meckel's ganglion, dentigerous cysts, fibrous epulis, draining of the antrum of Highmore.

If only a portion of the jaw need be removed, ample room may usually be obtained by making the first part of the incision described in the last operation, *i.e.* from the point a little internal and below the inner canthus of the eye, skirting the edge of the

nose to the middle line and then through the lip. This flap is thrown upwards and outwards after freeing it from the bone. If the alveolar margin and orbital plate can be left, horizontal saw-cuts can be made outwards from the nose, the outer ends being joined by a cut through the malar bone by means of the chisel. More room may always be obtained by completing the incision as if for complete removal of the bone.

NASO-PHARYNGEAL POLYPUS

The operation for removal of this growth will be considered here. The naso-pharyngeal polypus, for which the following operations are performed, is a fibrous and often sarcomatous growth, which takes origin from the roof of the naso-pharynx, and is firmly attached to the base of the skull at this point.

The growth is often somewhat pedunculated and when small may be snared or cut with the galvano-cautery, or twisted off.

But when large the serious hæmorrhage met with, and the incompleteness of such removal, call for a more extensive procedure.

The methods of operating may be divided into three groups, according to the route employed to approach the growth.

1. The oral route.
2. The nasal route.
3. The maxillary route.

1. The Oral Route

This is the easiest and simplest of the three methods, and gives excellent results.

(1) *Nelaton's Operation*

Instruments.—In all the following operations the ordinary instruments for the excision of bone should be provided. For the oral route long-handled cleft-palate needles and forceps, tracheotomy tube, a gag, and long-handled sponge holders are needed in addition.

Position.—This should be the ordinary position for operations on the naso-pharynx and mouth, *i.e.* the patient on the back with the head dependent over the end of the table, the vertex looking towards the floor, or if a preliminary laryngotomy is performed the head need not be extended so far. The surgeon

stands at the right side of the patient, with the assistant opposite to him.

Operation.—The mouth having been gagged open the uvular is seized with forceps and an incision made in the middle line with a knife, so as to divide it and the soft palate completely, the incision is continued forwards on the hard palate to a point half-way to the alveolar margin. From the anterior ends of this incision two transverse incisions, one on each side, are carried outwards and a little backwards.

With a periosteal elevator these two flaps of muco-periosteum are now detached from the hard palate and the soft palate freed from the posterior edge of the hard palate. By this means a quadrilateral portion of bone is exposed. The surgeon, with an osteotome and mallet, proceeds to remove this exposed portion of bone, together with the portion of the vomer lying above. Free access is then obtained to the base of the growth, which may be dealt with as thought fit, either detached with a periostea elevator, twisted off, or removed with the cautery. After the growth has been removed and all the bleeding arrested, the two muco-periosteal flaps are sutured together so as to reconstitute the palate.

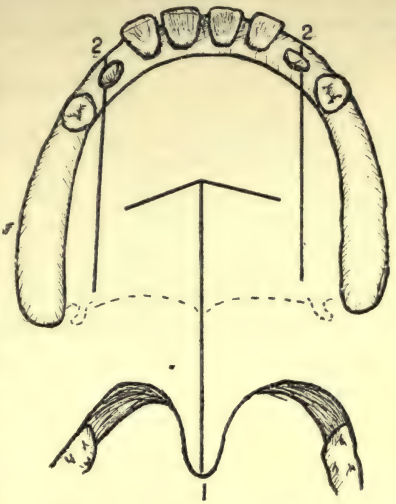


FIG. 72.—THE ORAL ROUTE.

Exposure of the phalanx by—1, Nelaton's method. 2, Chalot's method.

(2) *Chalot's Operation*

Operation.—The surgeon incises the fold of mucous membrane near the middle line, which is reflected from the gum on to the upper lip, so as to open into the anterior nares. The canine tooth on each side is then extracted, and the mouth gagged well open. Two incisions are now made, one on each side, from the posterior extremity of the hard palate forwards to the socket of the canine tooth. These incisions are practically parallel to one another, but the nearer they can be kept to the alveolar borders

the more room will be obtained. With a saw or an osteotome the hard palate is now divided along the lines of these incisions, the cut being carried up into the nares anteriorly. This flap of bone is next separated from the septal cartilage and the vomer and turned downwards into the mouth, the soft palate forming the hinge. When the polypus has been dealt with, the flap of bone is raised up into its place again and wired on either side to the alveolar margin of the upper jaw.

Comment.—Neither of these operations is very suitable for the larger forms of polypi, as the room in which to manipulate is limited; of the two the latter gives the better access, but is severer. Neither produces any deformity of the face.

2. The Nasal Route

Many operations have been devised to gain access to the naso-pharynx by this route; only two, however, will be indicated.

(1) *Lawrence's Operation* (*turning up the nose*)

In this operation the nasal cavity is exposed and the growth approached by turning the nose up in a flap.

Operation.—An incision is made starting at a point just

FIG. 73.—THE NASAL ROUTE.

Incision for turning the nose upwards (Lawrence).

FIG. 74.—THE NASAL ROUTE.

Incision for turning the nose downwards (Ollier).

internal to the lachrymal sac, and running down the side of the nose to the ala, round which it skirts; from here it is carried across the upper lip close to the columella of the nose, and skirting round the opposite ala is carried up on the other side to a point opposite the starting place. The cartilage of the nose is detached on either side and the nasal bones and nasal process of the superior maxilla freed with bone forceps. Next the septum of the nose is divided with strong scissors and thrown upwards, and the depths

of the nasal cavity are laid bare. The remains of the septum and some of the turbinated bones may require removal before the growth can be dealt with. After removal of the polypus the nose is replaced and carefully stitched in position.

(2) *Ollier's Operation (turning down the nose)*

In this the nose is turned downwards in a flap and the nasal cavity exposed.

Operation.—The incision commences in the groove at the side of the ala of the nose and is carried upwards to a point a little internal to the inner canthus of the eye. From here it is made to cross the bridge of the nose to a corresponding point on the opposite side; it is completed by carrying it down to a point opposite the starting place.

The bone is then sawn through in the line of the incisions and the nose turned downwards. The septum is pressed aside or removed and the growth dealt with. The nose is replaced in position and accurately sutured.

Comment.—The amount of room procured by these two operations is limited. They are best suited to nasal growths and small naso-pharyngeal polypi. Very little scar is noticeable after either method.

3. The Maxillary route

Langenbeck's Operation

In this a tongue-shaped flap is made from the cheek of the affected side; this is raised, together with the subjacent part of the superior maxilla.

Operation.—Two curved incisions are made, the upper starting from the nasal process of the frontal bone and curving outwards beneath the orbit to reach the prominence of the malar bone, the lower starting from the ala of the nose and curving outwards to join the first. If additional room is needed a third incision may be carried outwards from where these two meet. These incisions are carried through the soft parts down to the bone, but the flap thus marked out is not dissected up. The masseter muscle is detached from the malar bone at the outer end of the lower incision. The periosteum is stripped from off the floor of the orbit through the upper incision to expose the anterior end of the spheno-maxillary fissure. A fine key-hole saw is now introduced horizontally below the zygoma and made to enter the pterygo-maxillary fissure, then through the spheno-maxillary

fossa into the nasal cavity ; the end should be felt with a finger in the mouth. The saw is now made to travel upwards through the zygoma and forwards and inwards through the frontal process of the malar into the spheno-maxillary fissure and across to the nasal process of the superior maxilla just below the lachrymal sac, the saw following the line of the upper incision. The saw, re-introduced at the same point, is now made to cut horizontally forwards and inwards above the alveolar margin of the superior maxilla to the nasal cavity along the line of the lower incision, a finger in the mouth guarding against injury from the point. In this last saw cut the antrum is traversed. An elevator is now introduced into the pterygo-maxillary fissure and the portion of bone thus marked out, together with the soft parts attached, is levered forwards and inwards. The hæmorrhage, which is severe, comes from the severed branches of the internal maxillary, ascending pharyngeal, and facial arteries. Good access is now obtained to the growth. After removal the osteo-plastic flap is replaced and accurately stitched in position again, the zygoma being wired on. It may be found much easier to divide the bone with a Gigli's saw. If possible the orbital plate should be left intact.

FIG. 75.—THE MAXILLARY ROUTE.

Langenbeck's operation with temporary resection of part of the upper jaw.

Though this operation is the severest of these described, it gives better access than the others.

EXCISION OF THE LOWER JAW

This may be partial or complete. In the former case a portion is taken away, as in the operation for epulis or in operations for epithelioma of the tongue which has involved the bone locally. In partial excision of the mandible an attempt should always be made to leave intact a bridge of bone near the lower margin of the jaw so as to preserve the outline of the bone and prevent deformity, but this is only to be done when the growth can be removed widely without damaging this portion of the bone. Æsthetic considerations do not justify the surgeon leaving suspicious tissue from which recurrence may take origin. In

the complete operation one half of the jaw is removed, the bone being divided at or near the symphysis.

Excision of half of the Lower Jaw (*see* Fig. 76)

Position.—The patient lies in the dorsal position, with the head either dependent or turned towards the sound side. The surgeon stands on the affected side with the assistant opposite him.

Operations.—The incision starts in the middle line just below the red margin of the lip, passes down to the symphysis and along under the lower border of the jaw to the angle ; from here the knife passes upwards along the posterior border of the ramus, but does not go higher than the level of the lobule of the ear for fear of injuring the facial nerve. The incision is carried down to the bone, the facial artery being caught and divided between two ligatures just before it passes over the margin of the jaw in front of the masseter. The soft tissue are separated from the outer surface of the jaw and the flap turned up on to the cheek, the cavity of the mouth being opened into. The central-incisor tooth is extracted and the bone sawn partially through to one side of the symphysis. By this means the genio-hyoid and genio-hyoglossus muscles, which are attached to the genial tubercles, escape damage, and the movements of the tongue are not impaired.

The division of the bone, which is very hard at this point, is completed by bone forceps. The bone is then seized with lion forceps and drawn outwards, the knife freeing the inner side of the bone from the mucous membrane of the tongue, and severing the attachments of the anterior belly of the digastric and myolo-hyoid muscles. The bone is then depressed and the attachments of the internal pterygoid and masseter muscles on the inner and outer sides of the bone respectively are divided. The inferior dental artery and nerve and internal lateral ligament of the jaw will be now divided. Still further depressing the bone the coronoid process, with the insertion of the temporal muscle, comes into view ; the knife should cling closely to the bone at this stage for fear of injuring the internal maxillary artery, which runs between the neck of the bone and the internal lateral ligament of the jaw, and is therefore liable to be brought into the wound if the jaw is everted, while the latter structure is undivided. The tendinous insertion of the temporal muscle is divided bit by bit as the jaw is depressed. The external pterygoid is cut and the head of the bone twisted out of its socket. All hæmorrhage is now arrested. This comes from the branches of the internal maxillary artery,

the trunk of which should escape injury if the edge of the knife has been kept against the bone. The flap is then brought down and stitched in position ; if the red line of the lip has been divided, as in large growths, then special care must be given to the accurate suturing of this portion of the flap. A drain can be inserted at the angle posteriorly for the first day or two.

After-treatment.—The patient should afterwards be propped up in bed and encouraged to irrigate his mouth with warm water containing some potassium permanganate. Stimulants and fluid nourishment may be given by the mouth by means of a tube passed well back into the pharynx. For the rest the sooner he is up the better.

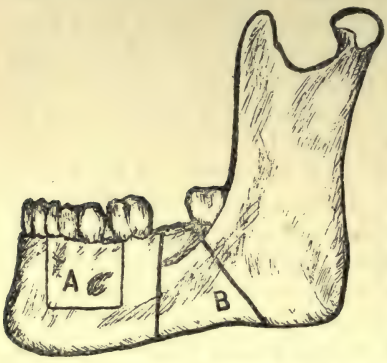


FIG. 76.—PARTIAL EXCISION OF THE MANDIBLE.

A, Removal of a portion of the lower jaw, a bridge of bone being left to maintain the contour. B, Removal of a wedge-shaped piece for ankylosis of the jaw (Esmarch's operation).

Comment.— Considerable deformity follows these operations, as the sound half is drawn over to the opposite side. After a while a fibrous mass forms in the site of the excised bone. If it is impossible to save the symphysis and the muscles attached to the genial tubercles, a stout silk suture should be passed through the tip of the tongue and fastened by strapping to the cheek in order to prevent the tongue falling backwards and impeding respiration. If the growth has expanded the bone posteriorly, the coronoid process may hitch against the malar bone when attempts are made to depress the jaw. In that case the process should be nipped off with bone forceps and dealt with separately.

When a diseased bone is depressed strongly it is apt to fracture, and has to be taken away in two or more pieces.

Partial Excision of the Lower Jaw

This may be performed for epulis, cysts, necrosis, or for ankylosis of the tempero-maxillary articulation.

1. *Operation for Epulis*

Operation.—Only the general outline can be given as the proceeding varies with the extent of the disease. The operation

can usually be performed satisfactorily from the mouth, either with or without an incision in the cheek to gain more room. The mouth having been gagged open and the portion of the bone to be removed satisfactorily exposed, the teeth, if any are present, are removed from this portion of the bone. With a scalpel the soft tissues are divided down to the bone over the part to be removed. Then with a chisel and mallet or a fine saw a wedge-shaped portion is excised if the growth is small; if large a quadrilateral-shaped portion must be removed, care being taken to leave, if possible, a bridge of dense bone along the lower margin of the jaw to prevent deformity. The hæmorrhage is then stopped and the wound stuffed and allowed to granulate up from the bottom.

The same procedure is followed, together with some form of plastic operation on the lips or cheek, in the case of epithelioma of those structures if the bone is invaded. (*See* Plastic Operations.)

2. *For Fixity of the Jaws*

Fixity may be brought about by ankylosis of the joint from suppuration, chronic rheumatic arthritis, or by the contraction of scar tissue in extensive burns, etc.

For conditions only affecting the joint itself, removal of the condyle will be sufficient, and a portion of the bone below.

Excision of the Condyle

Operation.—An incision one and a half inches long is made directly over the condyle, starting on a level with, and a little in front of the tragus, and running forwards along the lower margin of the zygoma. By starting a short distance in front of the tragus, the superficial temporal artery and the auriculo-temporal nerve are avoided. The incision is above the level of the transverse facial artery, which runs forward about half an inch below the zygoma. As the wound is deepened the branches of the facial nerve and the lobules of the parotid gland are exposed and drawn aside. The fibres of the masseter are cleared from their attachment to the zygoma, if necessary, also from the outer surface of the jaw, and the joint exposed. A blunt hook is now passed round the neck of the bone to steady it, and the condyle separated by the chisel, mallet, and bone forceps; the head of the bone is then seized with sequestrum forceps and twisted, while the knife severs any remaining attachments, such as ligaments and the insertion of the external pterygoid muscle.

More bone can be removed now if needed with the bone forceps. If the condyle is firmly ankylosed to the glenoid fossa, care must be used that the cranial cavity is not entered in attempts to dislodge the head of the bone; in these cases it is often better to leave the head and remove more bone from the neck and ascending ramus. Before the patient recovers from the anæsthetic the jaws should be prized apart as widely as possible, as the opposite jaw will have become stiff through non-use. Bone must be removed freely if a good result is to be obtained. Sometimes the operation has to be repeated on the opposite side. Some amount of temporary facial paralysis is often met with after this operation.

Esmarch's Operation

When fixity is caused by scar tissue it is necessary to remove a portion of bone in front of the scar. Esmarch's operation consists in the removal of the large wedge-shaped portion of the bone well in front of the cicatrix, which in these cases is usually over the region of the masseter.

Operation.—An incision about two to two and a half inches long is made in front of the scar along the lower border of the jaw. The incision goes right down to the bone; the facial artery will probably have to be secured between two ligatures. A triangular wedge of bone, measuring one and a quarter inches at its base and three-quarters of an inch at its apex, is now removed with saw and bone forceps. The apex, if possible, should correspond to an edentulous gap; if none is present a tooth should be removed at the apex of the triangle. The large dental artery running in the substance of the bone will bleed freely, and must be plugged with a small piece of gauze or wax. The jaws should be opened as widely as possible at once, and passive and active movements commenced early. A portion of the masseter muscle is sometimes turned in between the two fragments of bone to ensure non-union.

EXCISION OF THE CLAVICLE

Complete or partial removal of the clavicle may be resorted to on account of caries, necrosis, severe fracture with bad union, sarcoma, or for the relief of symptoms caused by backward dislocation of the sternal end.

Anatomy.—The bone being superficial in its entire extent is easy of access, but is firmly bound in position by the conoid, trapezoid, rhomboid and inter-clavicular ligaments. Powerful

muscles, such as the trapezium, deltoid, pectoralis major and sterno-mastoid are attached to the bone, while the subclavius separates the bone from the first part of the axillary vessels and the cords of the brachial plexus. The bone has one epiphysis situated at its sternal end ; this begins to ossify at the eighteenth, and unites with the shaft at the twenty-fifth year.

Position.—The patient lies on the back with the shoulder slightly raised and the head turned to the opposite side, the arm is well pulled down and lies by the side. The surgeon stands on the affected side with the assistant opposite him.

Operation.—An incision commencing over the sterno-clavicular articulation is made, extending outwards along the line of the bone to end over the acromio-clavicular articulation. This incision is made down to the bone. The bone is cleared of the soft parts in front. If the excision is performed for reasons which permit of the leaving of the periosteum, that is divided longitudinally and stripped back from the bone ; in sarcomata the periosteum is removed with the bone. A Gigli saw is now passed round the junction of the outer and middle thirds, or a key-hole saw used, and the bone divided. The acromial portion is now seized with lion forceps at its inner end and drawn forwards, while the muscles and ligaments are divided with a knife, care being taken to keep the edge of the knife against the bone all the time. The acromial portion having been removed, the sternal portion is treated in the same manner, the sternal part of the sterno-mastoid muscle, the rhomboid, capsular, and interclavicular ligaments being cut through. The close proximity of the large vessels and phrenic nerve to the inner end of the bone should be borne in mind. The bleeding having been arrested the wound is closed.

The place of the bone, if completely removed, is taken later by a tough band of fibrous tissue.

In partial excision only one end of the bone is removed, the incision only extending over that half of the bone. The steps of the operation are the same, only one half being dealt with.

EXCISION OF THE SCAPULA

Excision of this bone is performed for the eradication of sarcoma. In most cases the operation is of a partial rather than complete type, owing to the importance of retaining the glenoid cavity, acromion, and coracoid processes, these points being of great importance in relation to the subsequent usefulness of the arm.

Position.—The patient lies on the sound side with the scapular

region exposed, the surgeon standing behind the patient with the assistant opposite him.

Operation.—Two incisions are made, one extending from the superior to the inferior angle, lying parallel and a little external to the vertebral border of the bone, the second incision starting over the acromion process and running along the spine of the scapula to join the first incision at a right angle. These two incisions divide everything down to the bone. The two flaps are then dissected up, including the muscles, trapezius, and deltoid, which are detached from the spine and acromion in the upper and lower flaps respectively. The upper and vertebral borders of the bone are then cleared, the omo-hyoid, levator anguli scapulæ, and rhomboids being divided in turn. The supra-scapular and posterior scapular arteries will be cut and ligatured at this stage. The vertebral border is pulled outwards and the serratus magnus muscle detached. The bone is next rotated so as to bring out the coracoid process; the tendons of the pectoralis minor and short head of the biceps and coraco-brachialis muscles, conoid and trapezoid ligaments are divided close to the process. The posterior aspect of the capsule of the shoulder joint, together with the muscles inserted into it, viz. supra spinatus, infra spinatus, and teres minor, are divided; the long head of the biceps is reached within the joint. The glenoid cavity being pulled upwards, the long head of the triceps is divided and the anterior aspect of the capsule of the joint with the subscapularis tendon is severed.

The large subscapular artery will be met with now or after the next step, when the teres major muscle is divided. The entire bone can now be removed. The bleeding being arrested, the flaps are brought into position and the wound closed, a drain being placed in the lower part of the wound and the arm secured to the side.

Comment.—If it is found possible to leave any one of the acromion, coracoid, or glenoid processes, the muscles attached to these need not be removed unless in the way, and the processes can be sawn through and left *in situ*. The bleeding comes from the vessels which take part in the anastomosis round the scapular, viz. the supra-scapular, posterior scapular, acromial branches of the thoracic axis artery, and the subscapular, the last-named being the largest. The subscapular artery should be secured before the dorsalis scapulæ branch comes off. The subclavian artery may need to be compressed during the operation. If the operation is carried out for sarcoma, the muscles arising from the bone and going to be inserted about the head of the humerus will be left attached to the scapula, and removed with that bone, only their insertions being severed as above indicated. The use of the limb is impaired for work above the head, but many movements can quite well be carried out, such as lifting light weights, etc.; the arm is not so seriously affected as might be thought, especially if the muscular processes are left intact.

EXCISION OF THE RADIUS AND ULNA

This is of a partial nature in the case of both bones, being called for in severe injuries, necrosis, myeloid sarcoma, or in the deformity which may follow a diastasis at the lower end of the

radius, the epiphyseal plate ossifying while the ulna continues to grow. The radius is one of the common sites for the occurrence of myeloid sarcoma.

The Ulna

The ulna, owing to its superficial position, may be easily reached by an incision along the prominent posterior border of the bone, the incision lying between the extensor and flexor carpi ulnaris in the lower two-thirds of its course, and between the flexor carpi ulnaris and anconeus in the upper third. In partial operations the incision will lie along only a part of this line. Whenever the disease permits, the bone should be removed sub-periosteally. The fact that the dorsal cutaneous branch of the ulnar nerve passes round the inner border of the ulna to reach the dorsum about three inches above the styloid process must be remembered.

The Radius

Many of the statements made in connection with the ulna may be also applied to excision of the radius.

The incision starts on the outer side from the styloid process, and passes upwards in the interval between the supinator longus and the extensor carpi radialis longior. The incision extends a variable distance according to the amount of bone to be removed. As the incision is deepened the radial nerve must be drawn to one side. The supinator longus and the pronator radii teres are separated from their insertions and the soft parts freed as far as possible from the front and back of the bone. The radius is then sawn through as high as is found necessary. The upper end is drawn outwards with forceps, and the muscles and interosseous membrane separated from the inner aspect. The wrist joint is opened and the lower end disarticulated. All hæmorrhage is arrested and the wound closed.

The results of these operations are good. A variable amount of deformity will follow, more marked in the case of the radius as the hand will be carried to the outer side of the wrist. A leather support has to be worn for some time to steady the hand. If the bone has been removed sub-periosteally this support can be left off with the formation of a new bone. The movements of the fingers are interfered with very little. If the lower epiphysis of the radius can be left the deformity of the hand is lessened.

EXCISION OF THE METACARPALS

Anatomy.—The metacarpal bones have occasionally to be removed for tubercular disease, injury, or tumour growth. It should be remembered that a marked difference exists between the ossification of the first metacarpal and the others of the series. The epiphyses of the inner four metacarpals are situated at their distal ends and constitute the heads of the bones, while the metacarpal of the thumb and all the phalanges have the

epiphysis at the base of the bone. The epiphyses of all begin to ossify in the third year and unite with the diaphysis about the twentieth year

Removal of the First Metacarpal

An incision extending the whole length of the bone is made on its outer and posterior aspect, lying to the outer side of the extensor tendons, the ends of the incision should lie over the joints at either extremity of the bone. The digital branch of the radial nerve passing to the outer side of the digit lies to the inner side of this incision on the dorsum. The periosteum is incised when it is possible to leave it, and is separated, together with the soft parts, from off the bone. The head of the bone is freed first, grasped with forceps and pulled out of the wound. If it is possible to leave the head the bone is divided just above the joint, the periosteum now being freed from the deep surface towards the base. In young subjects the epiphysis with the extensor ossis metacarpi pollicis tendon is, if possible, left *in situ*. If it is necessary to remove the epiphysis the tendon must be cut, the carpo-metacarpal articulation opened into and the bone twisted out. The wound is then stuffed if the periosteum is left, and only partially closed to allow the formation of a new case of bone. The relation of the radial artery must be kept in mind. The vessel lies on the dorsum of the first carpo-metacarpal articulation and then passes to the inner side of the base of the first metacarpal, lying between it and the second as it passes forward into the palm.

Excision of one of the four Inner Metacarpals

Here the incision is made directly over the dorsum of the bone. The soft parts are pulled aside with the periosteum. The head of the bone can then be freed and the operation completed as in the case of the thumb, or the bone may be nipped in two, the halves being removed separately.

Excision of the Terminal Phalanx

The terminal phalanx is the only one ever excised in practice, as the others, if removed, give a very useless digit. The terminal phalanx can best be removed by making a U-shaped incision round the free end of the nail. The little epiphysis should be left, as to it is attached the tendon of the flexor profundus

digitorom in front, and the central part of the dorsal expansion of the extensor communis digitorum behind.

SEQUESTROTOMY

As this operation is most frequently performed on the tibia, it will be described as carried out on that bone.

This operation is performed at a varying time after the onset of the inflammation which caused the localized death of the bone. By this time the periosteum has formed a new sheath of bone, the involucrum, which is pierced by the cloacæ through which the discharge escapes. Inside this involucrum lies the sequestrum or dead bone, more or less separated from the living tissue, and perhaps loose. The object of the operation is to remove the sequestrum which is keeping up the discharge and so allow the interior of the involucrum to granulate up.

Instruments.—The ordinary instruments for the excision of bones.

Position.—The patient lies on the back with the leg raised on a sand bag. The surgeon stands on the affected side.

Operation.—An incision of sufficient length is made over the inner surface of the bone; this may be made to pass through one or more of the sinuses. The soft parts, including the periosteum, are retracted and with a chisel and mallet the involucrum is now divided sufficiently to allow of the removal of the sequestrum. The latter may need to be divided with bone forceps before it can be extracted. If the sequestrum is large an osteoplastic flap may be raised up and the interior of the involucrum thus laid bare. After the removal of the sequestrum the interior of the bone is washed out, the unhealthy granulations scraped away, and an attempt made to render the cavity aseptic by swabbing it with pure carbolic or zinc chloride (40 gr. to the oz.), the excess of either being washed off. The sinuses are cut out and the flap replaced after the wound has been packed, an opening being left for drainage at the lower part. If the wound has been rendered aseptic it may be closed, and organization of blood clot hoped for to fill the cavity in the bone. Or the cavity may be filled with small portions of decalcified bone. The success of the last two measures depends entirely on whether or not the cavity has been rendered aseptic. If the wound cannot be rendered aseptic, then it must be allowed to heal up from the bottom by granulation tissue, a tedious process in the majority of cases.

EXCISION OF THE ASTRAGALUS

This bone is removed for tubercular caries, irreducible or unreduced dislocation, and for the relief of some forms of talipes. The operation may be carried out through a single external incision, but it is more easily performed by using an internal incision as well. Excision by a transverse wound is also described.

By an External and an Internal Incision

Operation.—The outer incision, about two and a half inches in length, commences just above the level of the ankle joint, in

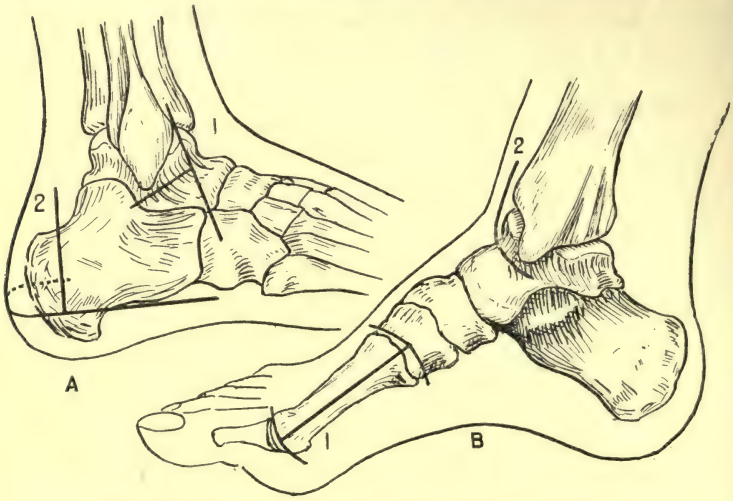


FIG. 77.—EXCISIONS OF TARSALS AND METATARSALS.

A 1, Outer or lateral incision for removal of the astragalus; 2, Excision of os calcis. **B** 1, Excision of 1st metatarsal bone; 2, Inner or medial incision for removal of the astragalus.

front of the external malleolus, and runs downwards and forwards to end over the cuboid, about one inch internal to the styloid process of the fifth metatarsal. This incision passes posterior to the tendon of the peroneus tertius and external division of the musculo-cutaneous nerve. From about the middle of this incision a short cut is made backwards and downwards to end just below the tip of the external malleolus. These two small flaps are dissected up and the ankle joint opened into. The ligaments of the ankle joint are freed from the neck of the bone

anteriorly, the anterior and posterior portions of the external lateral ligament of the ankle joint are divided externally. The astralago-scaphoid articulation is then opened into and the ligaments freely divided. The knife is then pushed into the tarsal sinus and the strong interosseous calcaneo-astragaloid ligament is severed. The tendons must be protected with retractors while the foot is manipulated to bring the above structures into view in turn.

An inner J-shaped incision about two inches long, commencing just below the tip of the internal malleolus, is carried forwards and then upwards, so as to lie in front of the internal malleolus. This incision is made to open into the ankle joint and the ligaments of the astralagus on the inner aspect of the foot are divided. The foot is now strongly extended and inverted, lion forceps are introduced into the outer wound, and the bone is twisted out.

The wound is closed with a drain in the lower part of the external incision. The foot is put up in a splint with the foot at right angles to the leg.

If the bone has been removed for tubercle the articular surfaces will need careful inspection to see that the disease has not already extended to them. Should it have done so then the diseased tissue should be removed before the wound is closed.

The use of the foot is very little impaired by this operation, when the small amount of shortening has been rectified by raising the heel of the boot.

When the bone is removed by an external incision only, a J-shaped one similar to the above is made, the inner ligaments of the bone being freed from the outside through the joint.

Removal of the bone by a **Transverse Incision** is sometimes done. An incision is made across the dorsum of the foot from the tip of one malleolus to the tip of the other. This incision divides everything down to the bone and opens the joint. The tibialis anticus, extensor proprius hallucis, extensor longus digitorum, and peroneus tertius tendons are all divided, the dorsalis pedis vessels are caught, between the extensor proprius hallucis and the extensor longus digitorum tendons, lying in front of the neck of the astragalus ; the long saphenous vein is caught at the inner end of the incision. The anterior tibial and musculocutaneous nerves are divided. After the removal of the bone the tendons are all carefully sutured together again, the nerves being similarly dealt with, and the synovial sheath of the tibialis anticus is closed. A drain is put in at one end of the wound as before. This method has only the advantage of giving rather

more room than the method first described. The disadvantages are obvious.

EXCISION OF THE OS CALCIS

The removal of this bone is required in tubercular disease, more often found limited to this bone than to any other bone of the tarsus, or for acute necrosis and for injuries.

Many methods have been devised for removal of the bone. They agree for the most part in having one horizontal incision, extending from near the base of the fifth metatarsal round the posterior aspect of the heel to the inner side of the tendo-Achillis. They differ from each other only in the position of the second incision. Thus Kocher adds a longitudinal incision running up the inner margin of the tendo-Achillis for three inches; Jacobson and Stewart add a transverse incision from the anterior extremity of the one described, which runs outwards half-way across the sole. These authors also place their horizontal incision on a level with the upper border of the os calcis. Landerer recommends a mesial longitudinal incision, extending from the tendo-Achillis over the prominence of the heel into the sole. He is able by this incision to remove not only the os calcis, but, if necessary, all the other bones of the tarsus in addition. The scar is said not to interfere with the subsequent use of the foot. The method of Farabeuf will be described here.

The os calcis has an epiphysis at the posterior extremity of the bone which begins to ossify at the eighth year. It joins the rest of the bone after the sixteenth year.

Position.—The patient lies slightly on the sound side, with the foot rotated inwards and supported on a sandbag. The surgeon stands on the affected side, with the assistant opposite him.

Operation.—The horizontal incision begins just behind the styloid process of the fifth metatarsal bone and extends back above the outer border of the foot and prominence of the heel, and then forwards to reach the inner surface of the bone. A vertical incision, two inches long, meets this at right angles, lying just in front of the outer border of the tendo-Achillis (*see* Fig. 77).

These two incisions are deepened to expose the bone. The peroneal tendons, which lie just in front of the vertical incision, must be left untouched. The soft parts are now separated up from the outer and under surfaces of the bone. The tendo-Achillis is cut at its insertion, the peroneal tendons are lifted

upwards and forwards, the longus being pushed over the peroneal tubercle. The central portion of the external lateral ligament of the ankle and the outer astragalo-calcanean ligaments, and the interosseous astragalo-calcanean ligaments are divided, the last in the tarsal sinus. As far as possible the inner and under surfaces of the bone are cleared. The calcaneo-cuboid joint is opened and the ligaments are divided. The os calcis is then seized with lion forceps and twisted out, the remaining structures being divided as they are seen. If the bone is tubercular the neighbouring joints are inspected to make sure they are healthy before the flap is replaced and sutured in position, drainage being provided for. As far as the disease admits the operation should be carried out sub-periosteally.

EXCISION OF A METATARSAL BONE

For the metatarsals the description of the operation for excising the metacarpals is sufficient. The first metatarsal alone requires special mention.

In the first metatarsal the head and base of the bone are of such large size that, in addition to a longitudinal incision along the inner surface of the bone, a transverse one is needed at both extremities. Two flaps can thus be dissected up (*see* Fig. 77, B). In place of this incision a curved incision with the conversity upwards may be marked out and the flap dissected down.

EXCISION OF JOINTS

Excision of a joint may be necessary to remove tissues which are already seriously diseased or to remove disease which is evidently spreading and destroying the joint. In the former the essential features of the joint have probably already been destroyed by the disease, and to do good, joint and disease must be sacrificed widely. In the latter case the operation is performed in order to save the joint from destruction by the disease, everything in the joint being spared except the diseased tissue. In both cases complete removal of the disease is the primary object of the operation. The next thing to be certain of is that the limb left will be useful. If a stiff joint is probable the ankylosis should be allowed to take place with the limb in the most useful position. An operation which leaves a flail-like and useless limb is often inferior to an amputation. Tubercular

infection is the disease which most frequently calls for this treatment.

There is a third condition for which a joint may be excised, and that is the faulty position in which a joint may have been fixed by previous disease, or in the hope of obtaining a movable joint in place of the existing ankylosis.

Complete excision implies the removal of the ligaments, synovial membrane, and the articular ends of the bones.

Partial excision or erasion implies a less wide removal, and is usually performed in the subperiosteal manner. The ligaments are kept in continuity with the periosteum of the bones, so that the muscular attachments are interfered with as little as possible. In some cases the bony prominences to which the muscles are attached can be chipped off and left behind. If a good movable joint is hoped for, the preservation of the muscles and their nerve supply is essential.

Special Instruments.—In addition to the ordinary instruments, various periosteal elevators and raspatories are needed, together with saws, chisels, mallet, gouges, and sharp spoons, bone forceps, and lion forceps. The knife used should have a stout handle and a short blade, resembling a Syme's amputating knife.

Excision of the Wrist

Lister's Operation

Operation.—This is carried out by means of radial and ulnar incisions. The radial incision commences above, just to the inner side of Lister's tubercle on the back of the wrist. Thence it runs downwards parallel with and to the inner side of the extensor longus pollicis as far as the outer border of the second metacarpal bone, it then runs straight down the bone for half its length. It thus avoids the radial artery, which is further out. The tendon of the extensor carpi radialis longor is detached from the base of the second metacarpal, and the brevior is similarly detached from the third. The extensor longus pollicis and the radial artery are pushed outwards and bone forceps applied to separate the trapezium from the rest of the carpus.

The ulnar incision is made straight down the inner side of the limb from two inches above and rather in front of the end of the ulnar, to the middle of the fifth metacarpal bone on its palmar aspect. The wrist is extended to relax the tendons, which are next raised from the back of the carpus, the extensor carpi ulnaris being divided at its insertion. The dorsal and internal

ligaments of the wrist are divided. The anterior surface of the ulnar is cleared and the articulation of the pisiform bone opened, the wrist is bent to relax the tendons as the hook of the unciform is encountered and clipped off with forceps. The knife should not pass far down into the palm for fear of injuring the deep palmar arch. The anterior ligament of the wrist is next divided, and the junction of the carpus with the metacarpals divided with bone forceps. The carpus is grasped with sequestrum forceps and extracted through the ulnar incision. The hand is then everted, the radius and ulnar are protruded through the ulnar incision and the diseased ends removed with a saw, the tendons on the back of the radius are disturbed as little as possible. The inferior radio-ulnar articular surface is clipped away. The metacarpal bones are then protruded and their bases treated in the same manner till all the diseased portions are removed. It is often easier to deal with the second and third through the radial incision. The trapezium is dissected out, the tendon of the flexor carpi radialis being freed from the groove on its palmar aspect. The base of the first metacarpal is then removed. Lastly, the pisiform bone can be removed.

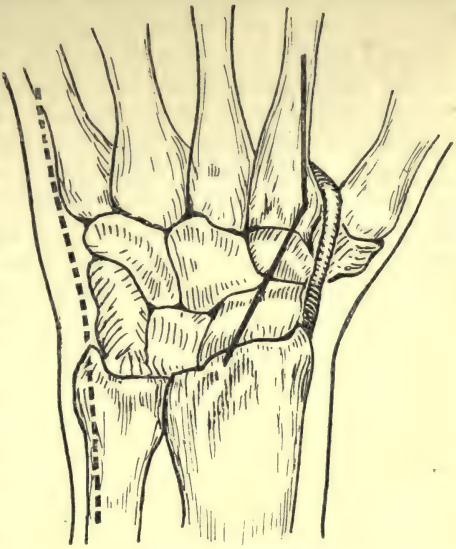


FIG. 78.—EXCISION OF THE WRIST-JOINT BY LISTER'S METHOD.

Comment.—It may not be necessary to remove the trapezium or the pisiform bones, as they each have separate joints which may not be infected.

After Treatment.—The hand is put up on a splint with the wrist extended and the thumb abducted. The splint should be worn for at least six weeks, during which time the fingers should be moved freely. The wrist does not require to be moved till the parts have consolidated. Later a leather support should be worn. Though pronation and supination are lost, a very useful hand results.

Excision of the Elbow

Position.—The patient lies on the back near the edge of the table, the surgeon stands on the side to be operated upon. An assistant stands opposite him and grasps the patient's hand, the limb being elevated and the elbow bent across the chest.

Operation.—An incision four inches long is made over the back of the joint, the centre of the incision being opposite the tip of the olecranon. The incision is made down to the bone, dividing the triceps and entering the joint behind (*see* Fig. 79).

2. *Clearing the Olecranon and Condyles of the Humerus.*—The surgeon should remember to keep the edge of the knife directed to the bones, which should be completely denuded of soft tissues, by this means muscular attachments are interfered with as little as possible. The inner condyle is usually cleared first, the inner half of the triceps being pealed off from the olecranon. The back of the internal condyle with the groove for the ulnar nerve is cleared. The internal lateral ligament is detached from both bones and the periosteum and muscular attachments to the internal condyle separated. The ulnar nerve should not be seen.

The outer part of the incision is dealt with in the same way, the anconeus being separated from the ulnar, and the external lateral and orbicular ligaments divided and turned aside with the supinator brevis muscle and the muscles attached to the external condyle. During this procedure the posterior interosseous nerve may be injured.

3. *Clearing and sawing the Ends of the Bones.*—The elbow is fully flexed and the end of the humerus protruded vertically upwards. The anterior ligament is freed from the front of the humerus as high as is needed, so as to clear the remainder of the bone. The end of the humerus is grasped with lion forceps and the arm steadied by an assistant who places the patient's hand prone on the table near the head. The bone is sawn through transversely.

The bones of the forearm are then made to protrude, and the attachments of the muscles to the coronoid process are separated. It is possible at this stage to injure the median nerve on the front of the joint. The olecranon is grasped with the lion forceps and the bones divided transversely, a slice of the upper end of the radius being removed at the same time.

The ends of the bones are examined to see that no disease is left, the wound is closed, and a drain is left in for 24 to 36 hours.

Comment.—Many other incisions have been used to expose

the joint, but the only other one in common use is the external J-shaped incision of Kocher.

Excision of the Shoulder

Position.—The patient lies near the edge of the table, the shoulder being raised on a sandbag. The surgeon stands on the outer side of the shoulder while an assistant supports the slightly abducted arm, the elbow of which should be kept bent to relax the long tendon of the biceps.

Operation.—*The Incision.*—The incision starts at the outer

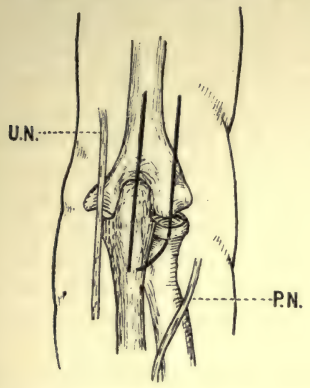


FIG. 79.—EXCISION OF THE ELBOW BY A POSTERIOR INCISION AND KOCHER'S EXTERNAL J-SHAPED.

P.N. Posterior interosseous nerve. U.N. Ulnar nerve.

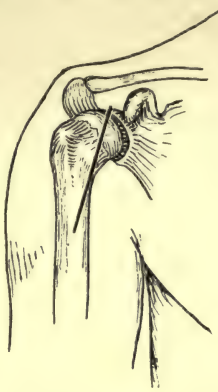


FIG. 80.—EXCISION OF THE SHOULDER JOINT.

side of the tip of the coracoid process, and is carried downwards and slightly outwards for 3½ to 4 inches (*see* Fig. 80).

The upper part of the incision is deepened through the fibres of the deltoid muscle, the lower part lies between the adjacent borders of the deltoid and the pectoralis major. The cephalic vein is avoided and the incision carried down to the bone. The bicipital groove is sought, it looks directly forwards. The tissues over it are divided and the capsule of the joint opened by running the knife up the groove to the outer side of the bicipital tendon.

2. *Freeing the Great Tuberosity.*—The tendon of the biceps is raised out of the groove and hooked to the inner side. The capsule of the joint is now freed with the soft parts from the outer tuberosity by cutting on to this part of the bone, while the

outer lip of the wound is strongly retracted. The assistant gradually rotates the arm inwards and depresses the elbow, so as to bring the structures under the knife. In this way the attachments of the supra- and infra-spinati and teres minor are divided.

3. *Freeing the Lesser Tuberosity.*—The arm is then rotated outwards and the elbow slightly raised, while the inner margin of the wound is retracted and the capsule and insertion of the subscapularis freed from the lesser tuberosity, the biceps tendon being carefully preserved.

4. *Clearing and removing the Head of the Bone.*—The head of the humerus is made to protrude from the wound by lowering the elbow until it is at right angles to the table, and then thrusting the humerus upwards. The capsule and synovial membrane can then be cleared from the back and inner aspects of the bone. The head is then grasped by lion forceps, which are held in the left hand while the saw is applied with the right hand to the upper part of the anatomical neck, the saw follows the line of the anatomical neck downwards and inwards. The glenoid cavity is examined and any diseased bone gouged away. Diseased synovial membrane under the subscapularis and along the bicipital groove is removed. A posterior opening is made for drainage by thrusting a pair of forceps backwards and cutting on their points; a tube is then introduced. The anterior wound is closed.

Comment.—The results of the operation are good, the disease can be thoroughly removed. It need not be necessary to divide the muscular insertions so freely, portions of the bone being left attached to the muscles. In children the whole of the epiphysis as a rule has to be sacrificed, and the growth of the arm is stunted.

Excision of the Ankle Joint

This may be carried out through a great number of differently planned incisions, according to needs, for the disease may not only call for removal of the lower end of the tibia and fibula, and part of the astragalus, but it may be found necessary to remove the whole astragalus and part of the os calcis as well.

Operation.—By an external J-shaped incision (Kocher).

1. *Incision and separation of the Capsule.*—The incision commences about three inches above the tip of the external malleolus, and sweeps down skirting the external malleolus to end at the tendon of the peroneus tertius in front. The tendon sheaths of the peroneus longus and brevis muscles are slit up and the tendons displaced forwards, they often have to be divided, and

are sutured again at the end of the operation. The periosteum is separated from the external malleolus and the joint opened into. The external lateral ligament is then separated from the fibula, and the capsule detached from the outer part of the astragalus and front and back of the lower end of the tibia as far as the internal malleolus.

2. *The Dislocation of the Foot and full Exposure of the Joint.*—The outer attachments being divided, the foot is forcibly dislocated inwards over the internal malleolus so that the sole looks upwards and the upper surface of the astragalus downwards. If the internal malleolus is diseased the bone is crushed during this manœuvre, this, however, is no disadvantage, as the crushed bone is subsequently removed. The interior of the joint is fully exposed and the diseased portions can be removed. The synovial membrane should be clipped away and the softened bone gouged from the internal malleolus and lower end of the tibia, a saw is seldom needed. The astragalus may be partly removed with the saw or the whole bone excised. A part of the os calcis may be removed at the same time.

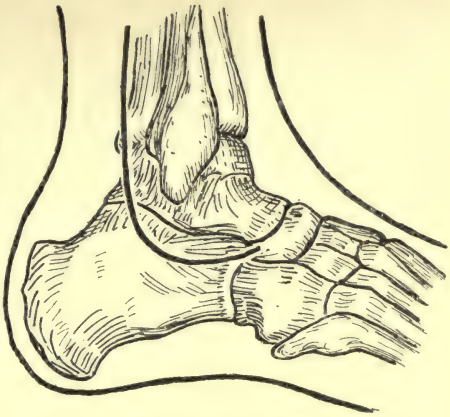


FIG. 81.—EXCISION OF THE ANKLE.

3. *Reposition of the Foot.*—When all the disease has been dealt with, the foot is replaced in position; the periosteum and ligamentous attachments on the inner side having been very little interfered with, and the external malleolus being largely intact, lateral displacements of the foot are prevented. The peronei tendons are sutured together and the wound drained for twenty-four hours. The foot is fixed at right angles to the leg till the wound is healed.

Another method which produces very good results is to divide everything transversely in front of the joint, the tendons being caught and united again at the end of the operatiou. The joint is widely opened and the diseased portions removed.

Comment. — Excision of the ankle in suitable cases gives most excellent results, a freely movable joint being obtained by both these methods. Kocher's is a little more difficult to

perform, but inflicts less damage on the muscular arrangements round the joint. Disappointment will ensue if it is hoped to cure widespread tubercular disease of the tarsal bones and joints by excision of the ankle. Such a condition calls for a Syme's amputation, which is infinitely superior in its results to any of the operations which attempt to excise the whole tarsus while conserving the forepart of the foot. It is also superior to Pirogoff's amputation, which retains a part of the diseased tarsus.

Excision of the Knee Joint

By excision of the knee is meant the removal of the bony surfaces as well as the synovial membranes and ligaments. The knee is one of the few joints from which we can literally excise the whole articular apparatus. Removal of the synovial membrane only or with a very limited removal of bone is termed erasion of the knee. A true excision will be described fully.

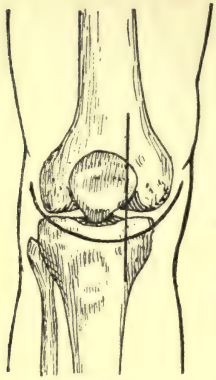


FIG. 82.—METHODS OF EXCISING THE KNEE.

Position.—The patient lies on the back near the edge of the table with the leg projecting over the end. During the operation the knee is usually flexed to about a right angle, the foot being planted firmly on the end of the table. The surgeon stands on the side to be operated upon with the assistant opposite him.

Operation by a Curved Anterior Incision

Operation.—*Where there is no doubt that the whole of the joint must be sacrificed:* 1. *Raising the Flap.*—The joint being bent to a right angle, the incision is commenced at the back of the further condyle and sweeps downwards to cross the front of the leg just above the tubercle of the tibia, and thence passes up on the near side to end opposite its starting point. The skin and fascia are dissected up from the front of the patella and sides of the joint. The flap is made to include the muscular tissues of the extensors as they appear in the wound. Above the patella the muscles are cut through to expose the upward prolongation of the synovial membrane, which is then pushed down from the front of the bone.

2. *Removing the Synovial Membrane and Patella.*—The flap

is then held back out of the way and the patella tendon divided and the capsular ligament separated from its attachment to the front and sides of the tibia. The capsule of the joint is then separated from the sides of the condyles of the femur. The cake of diseased synovial membrane, together with the patella, is then raised and removed by dividing the remaining portions of the synovial reflection below the patella—the ligamentum, mocosum and ligamenta alaria. The whole of the interior of the joint is now freely exposed. The crucial ligaments are divided.

3. *Sawing the Bones.*—The knee is still further flexed and the foot planted firmly on the table. The femur is cleared at the proposed saw line and the bone sawn from before backwards on to the tibia. During the sawing the soft parts are retracted and protected by a bandage retractor. Particular attention must be paid to the plane of the saw cut. In an antero-posterior direction it must be at right angles to the long axis of the bone, while in the transverse direction it must be precisely parallel to articular plane of the condyles. As the saw sinks deeply into the bone the handle of the instrument should be raised and a few strokes given specially to complete the section of the further condyle, the handle is then lowered and the next few strokes applied chiefly to the near condyle. The last few strokes should be cautiously made so as not to injure the soft parts. The upper end of the tibia is drawn forwards and the tissues cleared with the knife from the sides and back of the bone. The leg should be held in a vertical position and the saw applied from the before backwards and held parallel to the articular surface. As the section of the bone approaches completion attempts may be made to raise the articular surface by gently raising the back of the saw, the back of the bone cracks through, and the fragment can be freed from its remaining attachments with the knife. The bones are then laid together to see that the sections have been properly made.

4. *Removal of the rest of the Diseased Tissues.*—The ends of the bones are examined, and any remaining disease is gouged away. The prolongation of synovial membrane round the back of the condyles and under the semi-membranosus muscle is cleared out. Every trace of disease should be removed.

5. The bones are then laid in position, and may be either pegged or screwed together if desired. The wound is closed and the limb firmly fixed on a posterior splint with a foot-piece.

In cases where it is not so evident that the whole joint must be sacrificed the operation may be modified as follows :—

(1) The same incision is made. This is deepened through the

patella tendon and the joint opened at once. The capsular ligament is freed on each side below, and the patella thrown up in the flap. The crucial ligaments are divided.

(2) The necessary amount of bone is sawn from the femur and tibia as before.

(3) The synovial membrane is removed with forceps and curved scissors, and it may be found necessary to remove the patella.

The remainder of the operation is the same.

Other methods of operating have been advocated as by—

A transverse cut over the front of the patella, which is then sawn in half and the anterior of the joint opened and dealt with. At the completion of the operation the two halves of the patella are wired together. This method is seldom followed.

Langenbeck used a vertical incision placed on the inner side of the patella. The joint was opened and the patella dislocated outwards and the joint then bent to a right angle to expose the articular surfaces (Fig. 82).

Kocher recommends a vertical incision placed on the outer side of the patella, the lower part being curved forwards below the tubercle. The tubercle is detached with a chisel and the patella dislocated inwards and the joint then bent. It is more difficult to dislocate the patella inwards than outwards (Langenbeck's method) on account of the large size of the internal condyle.

Comment.—The anterior curved incisions give the freest access to the interior of the joint, and the operations are easy to perform. There is no advantage in dividing the patella. The vertical incisions do not give such a good view of the interior of the joint, and where a considerable amount of bone has to be removed there is little to be said in favour of retaining the patella.

The operation aims at (i) Complete removal of all the disease ; (ii) firm bony ankylosis in a good position ; (iii) rapid healing of the joint. If the bones are not fixed together there is a tendency for the tibia to be displaced backwards and a splint is needed, which will allow the wound to be dressed and at the same time ensure immobility.

Dr. Fenwick, of Montreal, recommends sawing the femur in a convex manner and the tibia in concave manner to ensure coaptation. This is also recommended by Kocher ; but it is easier to saw plane surfaces than corresponding curved ones. No more bone should be removed than is necessary to deal with the disease. The epiphyseal cartilage of the tibia lies in such close proximity to the joint that it frequently has to be sacrificed.

A high heel is necessary to compensate for the shortening. Relapses must be watched for and dealt with promptly.

Excision of the Hip

This operation implies removal of the head of the femur, the diseased capsule or synovial membrane and any diseased bone in the region of the acetabulum.

By a Postero-external Incision (Kocher-Langenbeck).

Position.—The patient lies on the sound side in the semi-

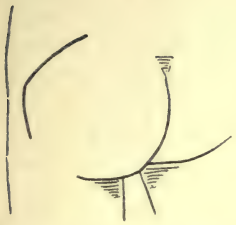


FIG. 83.—CURVED INCISION FOR EXCISION OF THE HIP.

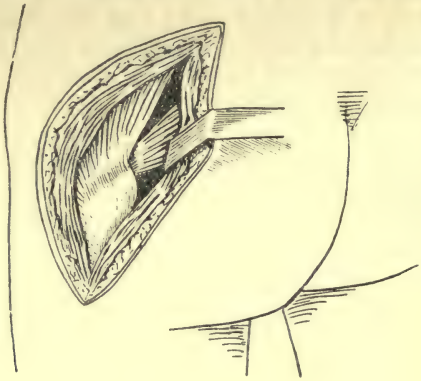


FIG. 84.—THE GLUTEUS MAXIMUS SPLIT, SHOWING THE ATTACHMENT OF THE MEDIUS TO THE LATERAL ASPECT OF THE GREAT TROCHANTER, THE PYRIFORMIS MUSCLE IN THE DEPTH OF THE WOUND.

prone position, with the hip and knee of the affected limb bent. The surgeon stands behind the patient.

Operation.—An incision is commenced at the outer side of the base of the great trochanter and passes vertically up to the tip of this process, from here it extends backwards and upwards for about three inches in the direction of the fibres of the gluteus, maximus. The wound is deepened through the coarse fibres of the gluteus maximus, to expose the great trochanter in the lower part of the wound and the gluteus medius in the upper part. The insertions of the gluteus medius and minimus are detached forwards with the periosteum, and the capsule exposed.

The capsule is opened above the pyriformis, and on rotating the thigh outwards the anterior portion can be separated from

the trochanter. On rotating the thigh inwards the tendon of the pyriformis can be detached and the capsule separated from the back of the neck of the bone. On rotating the limb further inwards the external rotators can be separated from the back and inner surface of the trochanter. The detachment of these structures is quite easy in a diseased joint. The ligamentum teres is divided by cutting on the head of the bone while the limb is flexed, adducted, and rotated inwards, the head of the bone is then dislocated backwards, and the whole of the interior of the joint is visible.

The required amount can then be removed from the head of the bone with a knife or a saw. The diseased bone of the acetabulum is gouged away and the whole of the diseased synovial membrane clipped or scraped off. The capsule of the joint is then sewn up posteriorly, drainage being allowed for the first twenty-four hours.

In performing this operation on the dead body of the adult, where the parts are presumably healthy, it becomes extremely difficult to dislocate the head of the bone, as the limb cannot be flexed and rotated as in the living. On the other hand, if the neck of the femur is divided by the chisel and mallet, or by an Adams' saw, the head can only be withdrawn with the greatest difficulty. For these reasons the operation is seldom set in examinations.

By an Anterior Incision

Position.—The patient is in the supine position with the thigh slightly flexed, abducted, and rotated outwards.

Operation.—The incision commences about half an inch below and to the inner side of the anterior superior iliac spine, and runs downwards and slightly inwards for four or five inches.

The interval between the sartorius and rectus femoris muscles is found, and the two drawn apart, so as to expose the front of the capsule.

The joint is opened and the neck of the femur sawn across in the direction of the wound, and the head removed. The interior of the joint is then searched for further disease.

Barker prefers to place the incision between the tensor fasciae femoris on the outer side and the sartorius on the inner side.

Comment.—The postero-external incision gives by far the better access to the joint, and allows a much more thorough operation to be performed.

CHAPTER VI

Operations on the Air Passages

Larynx—Trachea—Thyroid—Ribs

TRACHEOTOMY AND LARYNGOTOMY

Anatomy.—The trachea in the adult is about four and a half inches long, two of which are in the neck, if the head is held in the usual position, and two and a half are in the chest. With the head fully extended, the relative amounts in each region are reversed. The tube is very mobile, especially in children. The relative height of the cricoid differs with the age of the individual. At birth the cricoid corresponds with the lower border of the fourth cervical vertebra; at the fifth year it is on a level with the upper border of the sixth cervical vertebra, while in the adult it corresponds to the upper border of the seventh (Symington).

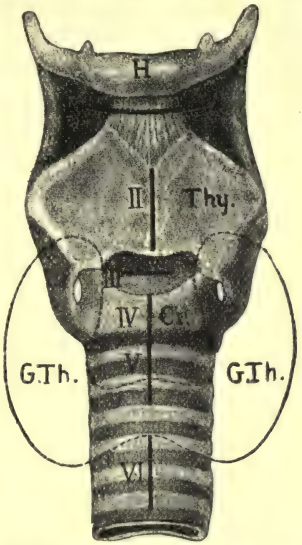


Fig. 85.—Operations on the Air Passages.
(*Rose and Carless.*)

I, Subhyoid pharyngotomy. II, Thyrotomy. III, Laryngotomy. IV, Cricotomy. V, High tracheotomy. VI, Low tracheotomy. H, Hyoid bone. Thy., Thyroid cartilage. Cr., Cricoid. G.Th., Thyroid body.

The pretracheal layer of the deep cervical fascia splits to form a sheath for the thyroid body and is continued up from the isthmus to become firmly attached to the front of the cricoid, so that whenever the larynx and trachea move, the thyroid body must move with it. The isthmus crosses the trachea opposite the second and third rings, but may be higher up and may be so broad as to conceal the fourth ring also.

In front of the trachea, below the isthmus in the diamond-shaped space left by the margins of the sternal depressors of the hyoid bone, lie the inferior thyroid veins. There may also be a thyroidea ima artery. In the infant there are the remains of the thymus, in addition to the innominate and the left common carotid arteries and left innominate vein, which in early life often distinctly encroach upon the neck.

The trachea may be opened above or below the isthmus, but the former situation is the one of choice and is the only one described here.

Position.—This is of more importance than in most operations. The patient, usually a child, lies on his back with his arms pinioned to the side by a sheet or blanket wrapped round the body above the elbows. The head is fully extended over the end of the table, the neck being supported by a sandbag. This steadies the trachea and draws the maximum amount into the neck. The anæsthetist keeps the head strictly in the middle line. A good light is necessary. The surgeon stands on the right side with an assistant opposite him.

Special Instruments.—Sharp and blunt hooks, trachea dilator, tracheotomy tube ready mounted with tapes, sterile feathers. There should be a choice of size of tubes, the one used should be the largest that the trachea will admit.

Operation.—The surgeon feels with his left hand for the position of the firm ring of the cricoid. This he grasps between the left middle finger and thumb, while with the ulna border of the same hand he keeps the point of the chin steady. *He should not relax the grasp of his left hand till ready to insert the tube.* An incision is made one to one and a half inches long downwards from the front of the cricoid. The wound is deepened and the assistant retracts the edges. The deep cervical fascia is cut loose from the cricoid by a transverse cut, the space in front of the trachea opened up by retracting the sterno-hyoid and sterno-thyroid muscles to the sides and forcibly displacing the isthmus of the thyroid downwards. By placing the left forefinger in the wound, the trachea can be felt plainly, although probably obscured by venous oozing. The surgeon must *see the rings of the trachea* before he cuts them.

A sharp hook is inserted under the cricoid, which is pulled forward by the assistant so that the trachea can be seen. When the trachea can be seen three rings are counted from the cricoid and with the edge of the knife towards the larynx the tube is stabbed in the middle line and the knife carried up to but not beyond the hook under the cricoid. The cricoid should on no

account be divided. If the tube is cut and not stabbed, there is a risk of displacing the thick mucous membrane inwards instead of dividing it. The characteristic sound of air entering is heard as soon as the knife opens the trachea. The assistant still holds the hook and sponges away the blood. The surgeon lays down the knife and inserts a dilator with his right hand; the left hand now releases the cricoid and larynx and inserts the tracheotomy tube. If no dilator is at hand, one side of the slit into the trachea is seized with toothed forceps and drawn outwards while the tube is inserted by depressing the opposite margin. When once the tube is in and *respiration fully established, and not before, can the hook under the cricoid be removed.* The tube is tied in place by means of the tapes. The wound is partially closed, and a dressing is slipped under the flange of the tube to cover the wound.

Comment.—Tracheotomy in the dead body, or when performed as a preliminary to other operations on the adult, is an operation of the simplest and easiest description. When performed in a hurry on a small child for the relief of dyspnœa, the operator is more beset by pitfalls and is more liable to make serious mistakes than in performing any other operation of the same magnitude. The trachea may not be found or when found and opened may be lost again, or the opening when made cannot be found; the cricoid may be cut or even the thyroid cartilage may be split; the œsophagus may be opened behind the trachea; the thyroid body cut and severe bleeding take place; or the operator may lose his way altogether and the large vessels of the neck may be divided.

The reasons for the difficulties are that the operation is often performed at night when the light is bad. Frequently there is great urgency and the hurry militates against accuracy; the engorgement of the vessels causes oozing from all cut tissues and obscures the view, while lastly the exaggerated movements of the small trachea are not easy to control.

In actual practice, many of these evils can be avoided by performing the operation before great urgency has supervened, and by operating in daylight. Other difficulties need not arise if the operator remembers—

(1) To grasp and retain hold of the cricoid until the trachea is opened.

(2) To keep in the middle line.

(3) To see the rings of the trachea, and not to be satisfied with feeling them.

(4) To keep the sharp hook under the cricoid until the tube is inserted and the respiration established through it.

(5) To avoid undue haste.

LARYNGOTOMY

Is performed as a temporary measure to allow the pharynx to be plugged during the performance of other operations.

Position.—As in tracheotomy, only the head need not be fully extended.

Operation.—The interval between the thyroid and cricoid cartilages is clearly defined. An incision, an inch and a half long, is made transversely over the middle of this space. (In some books, a longitudinal incision is still recommended ; it is inferior in every way to the transverse one). The incision is deepened and the deep fascia divided exposing the crico-thyroid muscles at each end of the wound. In the middle of the incision the crico-thyroid membrane must be seen as well as felt. A transverse incision is now made through the middle of the exposed membrane and the flattened laryngotomy tube inserted.

Comment.—This operation is exceedingly easy as compared with tracheotomy, but is suited only for adults.

EXCISION OF THE THYROID

Though not strictly an operation on the respiratory tract, it is convenient to describe this operation in this Chapter.

Anatomy.—The thyroid gland consists of two lateral lobes and an isthmus, small portions of thyroid tissue known as accessory thyroids may be present. The isthmus lies across the front of the trachea from the second to the fourth ring. Sometimes the isthmus remains unattached to one of the lobes.

The lateral lobes of the glands are covered by the depressor muscles of the hyoid bone and overlapped by the sterno-mastoid muscle. Their inner surfaces lie in contact with the insertion of the inferior constrictor of the pharynx into the thyroid cartilage, the crico-thyroid muscle, thyroid and cricoid cartilages, and the upper six rings of the trachea. The posterior margin of the gland is in relation to the carotid sheath, the inferior thyroid artery, the recurrent laryngeal nerve, and the lateral margin of the œsophagus on the left side.

The gland is enclosed in its own capsule and is surrounded

by a strong sheath formed by the pretracheal layer of the deep cervical fascia, which attaches the gland firmly to the thyroid and cricoid cartilages so that it follows the movements of the larynx on swallowing.

Occasionally when the lower part of one of the lobes enlarges, it does so in a downward direction and becomes incarcerated in the thorax and great difficulty is then met in releasing it from this situation.

The arteries of the gland are usually four but may be five in number. The superior thyroid arteries are given off from the lowest part of the external carotid and break up at the upper pole of the lateral lobe into three branches, of which the anterior is the most constant and extends down to the upper margin of the isthmus, across which it may form an anastomosis with the corresponding vessel of the opposite side.

The inferior thyroid arteries are derived from the thyroid axis, a branch of the first part of the subclavian. They run upwards and cross obliquely behind the carotid sheath about the level of the sixth cervical vertebra to reach the back of the lower pole of the gland, at which point they lie in close relation to the recurrent laryngeal nerve. The occasional fifth artery is the thyroidea ima, which is sometimes present and may replace the inferior thyroid arteries. It arises from the common carotid usually but may come from the innominate or from the arch of the aorta itself. When present it runs upwards in front of the trachea. The superior thyroid veins accompany the corresponding arteries and open into the internal jugular. The middle thyroid veins, usually two on each side, are often of large size in pathological conditions of the gland; they run transversely outwards from the front of the lateral lobes across the common carotid to the internal jugular vein.

The inferior thyroid veins run downwards side by side with many cross connections in front of the trachea to open into the left innominate vein in an irregular manner, sometimes by a common trunk, sometimes separately; occasionally the right one opens into the right innominate vein.

The blood vessels run chiefly in the layer of cervical fascia which forms the sheath of the gland, so that it is important to keep well within this layer, if hæmorrhage is to be avoided.

Position.—The patient lies near the right side of the table with the shoulders raised over a sandbag, while the head is allowed to fall back exposing the neck. The chin should be kept in the middle line. The surgeon stands on the right side. The operation is conveniently divided into steps.

Operation.—*Step* 1. *Incision and Exposure of the Gland.*—The curved incision is planned to lie transversely in the natural creases of the neck and is placed over the most prominent part of the tumour. The incision is curved with the convexity downwards while the horns reach well out over the sterno-mastoid muscle on each side. If only one lobe is to be removed the incision does not extend so far on the opposite side.

The platysma and fascia are divided, the superficial veins being secured at once. The depressor muscles of the hyoid bone are found thinned out over the surface of the thyroid gland. They are completely divided low down and reflected from the gland and their ends secured so as to be reunited later. The

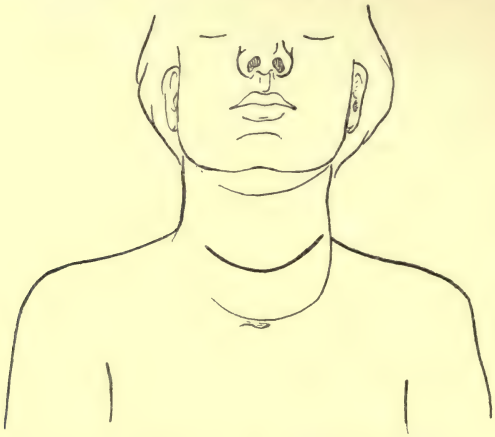


FIG. 86.—INCISION FOR THYROIDECTOMY.

sterno-mastoid muscle of one side is retracted and as much of the lateral lobe of the gland exposed as can be done conveniently.

Step 2. *Freeing the Gland and securing the Middle and Superior Thyroid Vessels.*—The fascial sheath formed by the pretracheal layer of the deep cervical fascia is divided. In it the large middle thyroid veins are seen passing from the front of the lateral lobe out across the common carotid artery to the internal jugular vein; they must be secured and divided between ligatures.

The superior thyroid artery is usually exposed quite close to the carotid sheath. Forceps are applied and the vessel ligatured. Great care must be exercised in opening up the fascial sheath of the gland not to damage the internal jugular

vein. Blunt instruments should be used and the gland should not be pressed upon.

Step 3. *Dislocation of the Gland and securing the Inferior Thyroid Vessels.*—When the posterior margin of the gland is free, the whole lateral lobe is dislocated forwards out of its bed. During this manœuvre, the trachea may be pressed upon and the respiration temporarily embarrassed, but if the sheath of the gland has been opened well up, dislocation can be performed rapidly and the embarrassment is quickly relieved. If the lateral lobe is drawn over to the opposite side, and the sterno-mastoid muscle retracted, the inferior thyroid artery will come at once into view, passing to the back of the lower pole of the gland from behind the carotid sheath. The artery breaks up into branches on the surface of the gland, and it is only at this spot that the vessel is in close relation to the recurrent laryngeal nerve. Forceps should be applied to the artery just as it emerges from behind the carotid sheath, as far from the gland as possible ; this avoids all risk of including the nerve in the ligature. The inferior thyroid veins are then secured.

Step 4. *Division of the Isthmus.*—A strong pair of forceps is applied to the junction of the isthmus with the lateral lobe and the tissue crushed so as to allow a ligature to include the remainder and prevent leakage of thyroid secretion into the wound. The lateral lobe is then freed by cutting on the distal side of the ligature.

The wound is dried out, all bleeding points secured and the ends of the cut muscles are united. The wound is then closed, drainage being provided for during the first twenty-four hours.

If both lobes are to be removed, the opposite side is dealt with in exactly the same way, the intervening isthmus being left behind. In all cases, some thyroid tissue must be retained.

Comment.—The dangers during the operation chiefly result from respiratory troubles during the necessary manipulations to dislocate the gland. In many cases the trachea has been severely pressed upon and its lumen may be narrowed to a dangerous extent, or its walls so thinned that they readily collapse with the slightest pressure. Dislocation therefore should not be attempted before the gland has been well freed from its sheath. The dangers of anæsthesia are nearly always dangers arising from interference with respiration. The recurrent laryngeal nerve must be avoided by securing the inferior thyroid vessel at a distance from the gland.

After the operation, especially in cases of exophthalmic goitre, a condition of hyperthyroidism may be met with, due to

the increased absorption of colloid substance. The temperature rises rapidly and the pulse becomes alarmingly frequent, 140 to 170 per minute, accompanied by great restlessness and anxiety on the part of the patient. Death may take place in these cases from heart failure. To prevent this complication the gland should be handled as little as possible so as to avoid massaging the colloid substance into the circulation, the isthmus is crushed and ligatured to prevent escape from the cut surface, rigid aseptic precautions are taken to promote rapid healing, and lastly a drain is inserted to carry off any leakage which may take place subsequently. In no case should the operator be tempted to perform tracheotomy, as an avenue for sepsis is thereby opened up.

RESECTION OF RIBS

Resection of a portion of a rib is usually undertaken to drain an empyema, and occasionally to evacuate a subphrenic or a hepatic abscess.

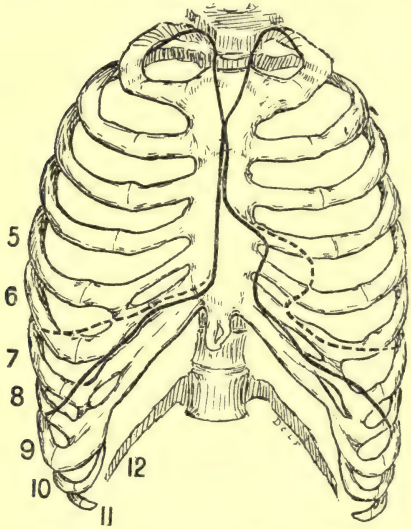


FIG. 87.—OUTLINE OF THE PLEURA AND LUNGS.

Outline of pleura in black; outline of lungs dotted.

The site of the incision is largely governed by the position of the collection of pus. If the empyema is pointing anywhere, the incision should be made over that place, if not pointing the position of the pus must be determined by percussion and auscultation. An exploring syringe should always be inserted before commencing the operation.

The ribs usually selected are the seventh, just in front of the posterior fold of the axilla, or the eighth, immediately in front of the lower angle of the scapula. The lowest part of the cavity is obliterated soonest, so the opening should be about opposite the middle or deepest part of the collection.

Anatomy.—The shape of the cross section of a rib should be borne in mind (*see* Fig. 89). The external intercostal muscle

is attached to the outer parts of the upper and lower borders of adjacent ribs. The internal intercostal muscle is longer and extends from the inner margin of the subcostal groove to the inner margin of the upper border of the rib below. In the subcostal groove and between the two muscles lie the intercostal vein, artery and nerve, in that order from above downwards. Behind the angle of the ribs the artery lies midway between the upper and lower rib so that exploratory punctures should not be made between the angle and the spinal column.

Covering the internal intercostal muscle is the pleura. In young subjects, the periosteum of the ribs is very thick and

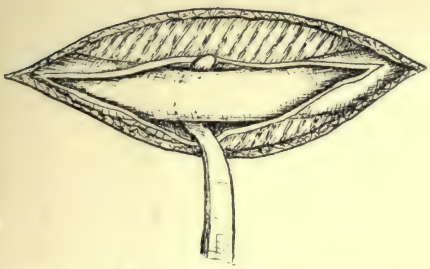


FIG. 88.—SEPARATING THE PERIOSTEUM FROM THE RIB.

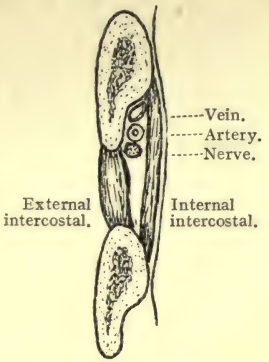


FIG. 89.—DIAGRAMMATIC SECTION OF AN INTERCOSTAL SPACE, SHOWING RELATION OF STRUCTURES TO THE PLEURA.

easily detached, in adults it is thin and adherent, so that it is difficult to avoid tearing it during operations.

Instruments.—In addition to the ordinary instruments, suitable curved periosteal elevators must be provided, together with bone forceps and a short wide rubber tube.

Position.—The patient lies rolled slightly on to the sound side, close to the edge of the table, the arm of the affected side being drawn out of the way. After the ribs have been counted and one chosen for resection, the arm should be moved to make sure that the lower angle of the scapula does not come down and cover the spot selected.

Operation.—An incision, three and a half inches long, is made directly over and in the long axis of the part of the rib selected. The integuments are divided and the muscles exposed, either the serratus magnus or the latissimus dorsi. The incision is deepened

through the muscles till the rib is laid bare. An incision is made through the periosteum of the rib for about an inch and a half in the long axis of the bone, a cross cut being carried across the rib at each end of the incision. With a periosteal elevator the periosteal flaps are reflected to the margins of the rib. In clearing the inner surface, the operator should always begin at the lower margin, as this part is separated from the pleura by the internal intercostal muscle. In fact, nearly half the inner surface of the rib is cleared of periosteum before the pleura is reached. Little clearing should be done at the upper margin of the rib beyond that necessary to clear the muscles. If this recommendation is attended to, there will be little likelihood of wounding the pleura inadvertently. A flat periosteal elevator with a suitable curve should be used to clear the rib. When the instrument has been made to appear at the upper surface of the rib, the remainder of the inner surface of the bone can be cleared by side to side movements.

Still leaving the periosteal elevator in place to protect the pleura, the bone forceps are applied to the extreme end of the bare rib, which is divided cleanly. The same thing is repeated at the other end of the bare portion of bone ; in both cases the bevelled sides of the forceps are towards the piece which is to be removed ; the instrument therefore must be reversed between the cuts.

The position of the vessels and nerve can be seen through the periosteum. A small incision is made through the periosteum in the long axis of the wound above the level of the vessels, and this is deepened until the pleural cavity is opened, or the actual opening may be made with sinus forceps. The sides of the opening are kept apart by thrusting in a pair of artery or sinus forceps and separating the blades, while the pus is allowed to escape. When the greater portion has escaped, the incision can be enlarged, avoiding the intercostal vessels. The cavity is then mopped out and its dimensions and position can be estimated at the same time. A short wide drainage tube is inserted and the wound partially closed.

The pleural cavity should not be flushed out, as sudden deaths have occurred during the flushing, probably from stimulation of the vagus nerve terminals.

Comment.—The student must remember to count the ribs before he decides which he is going to excise. There is always a tendency to operate lower down than is necessary or judicious. If the two layers of the pleura are glued together, the diaphragm may be divided and the recognition of the liver may be the first intimation of such a mistake.

CHAPTER VII

Operations on the Alimentary Tract

Tongue—Œsophagus—Abdomen—Intestines—Stomach—Large Intestine—Rectum and Anus—Liver and Bile Ducts.

THE TONGUE

Anatomy.—It will be remembered that the tongue is a bilaterally symmetrical organ, each side having its own muscles, arteries, and nerves; there is no communication between the vessels of the one side and those of the other, with the exception of a very feeble anastomosis near the tip. The surgeon is thereby enabled to remove one half of the tongue while leaving the other in cases where only one side is diseased. The chief artery to the tongue is the lingual artery, which arises from the external carotid often in common with the facial. As the artery runs along the upper border of the great cornu of the hyoid bone, it gives off the dorsalis linguæ, which is usually double. It passes between the hyoglossus and the genio-hyoglossus muscles. At the anterior border of the former it lies on the under surface of the tongue near the middle line and is now called the ranine artery. The ranine artery is continued on to the tip of the organ. The artery supplies branches to the tongue, sublingual gland and floor of the mouth.

The lingual vein lies on the outer side of the hyoglossus muscle, which separates it from the artery.

The hypoglossal and the lingual are the motor and sensory nerves of the tongue respectively. They both lie on the outer surface of the hyoglossus muscle, the latter above the former.

The lymphatics of the tongue are important, for it is found that whereas recurrence is rare in the stump left after removal of the tongue, it is common in the submaxillary and cervical glands. For this reason the glands should be removed in just the same complete manner as in cases of malignant disease of the mamma. The lymphatics of the anterior part of the tongue

pass with those of the floor of the mouth through the mylo-hyoid muscles to the submaxillary glands, the vessels and some of the glands lying actually in the submaxillary salivary gland. The lymph from the posterior part of the tongue passes back along the ranine vein and goes to the glands situated just under the angle of the jaw. From these two sets of glands the efferent vessels pass to the superficial cervical glands lower down, and through them to the deep cervical glands. Some vessels, however, pass direct to the deep cervical glands situated on the carotid sheath.

Methods.—The following operations will be described:—

1. Removal of a wedge-shaped portion of the tongue.

2. Complete removal of one or both halves of the tongue: By—(1) Whitehead's operation; (2) Syme's operation.

Preliminaries.—The preliminary measures which may be undertaken to ensure the success of the operation will be described here.

(*a*) *Cleansing of the Mouth.*—This should be done for several days before the operation is carried out. All carious teeth should be removed and the patient made to wash his mouth out frequently with a weak solution of potassium permanganate, or some such mild antiseptic. The teeth should be brushed night and morning.

(*b*) *Preliminary Laryngotomy or Tracheotomy.*—This is advised by some and has the advantage that the bleeding during the operation may to a great extent be disregarded, the danger from hæmorrhage during the operation being, not that the patient will bleed to death, but that the blood will be sucked into the air passages and set up an aspiration pneumonia. Tracheotomy is, however, not often carried out, but a laryngotomy is often performed, the tube being removed at the end of this operation. When laryngotomy has been performed, the back of the pharynx is plugged with gauze and the anæsthetic given through the tube.

(*c*) *Ligature of the Lingual Arteries.*—This may be carried out to arrest the hæmorrhage during the operation, and is a measure which is advocated and practised by many. It is specially indicated where the surgeon undertakes the removal of the sublingual glands at the same sitting as the removal of the tongue. The ligation of the artery is then easy through the same wound as that by which the glands are removed. If the whole tongue is being removed, then ligation of the artery on both sides is of great help, and does not add greatly to the length of the operation as time is saved owing to the small amount of hæmorrhage.

(*d*) *Removal of the Submaxillary Glands.*—These should always

be removed ; it is in many cases advisable to remove the glands, on one side, at all events, at the same time as the tongue is dealt with, the lingual artery on that side being secured as a step in the operation. Some surgeons prefer to clear out the glands at a separate operation. The submaxillary gland is removed, together with all the lymphatic glands, Wharton's duct being secured and ligatured, and the recurrent portion of the glands cleared out.

1. Removal of a Wedge-shaped Portion of the Tongue

Operation.—The tongue is secured on each side of the portion about to be removed by transfixing it with a needle threaded with stout silk. By means of these threads the tongue can be drawn forward and steadied. With a knife the mucous membrane is divided in a wedge-shaped manner, the base of the wedge being at the end of the tongue. The rest of the operation is performed with scissors by snipping through the muscular tissue little by little until the wedge-shaped portion is removed. All bleeding is then arrested, one or two buried sutures of catgut are inserted, and the mucous membrane brought together by interrupted sutures. Care must be taken not to remove too large a wedge, as the remaining portion of the organ will be too narrow when the lateral portions are approximated.

2. Complete Removal of one or both Halves of the Tongue

(1) *Whitehead's Operation*

Instruments.—A strong, straight, blunt-pointed pair of scissors, artery forceps, large curved needle, sponge-holders, ligatures, thick silk, and a gag, which is kept open by a catch mechanism and not by a screw.

Position.—The patient lies in the dorsal position, with the head turned towards the affected side, or if the whole tongue is to be removed, towards the right. The surgeon stands on the side to be removed ; some prefer to stand on the right side in all cases ; the assistant stands opposite him. The patient must be so arranged that a good light is thrown into the mouth.

Operation.—The mouth is gagged open from the less affected side and a silk suture passed through the tongue near the tip on each side of the middle line. With these threads the tongue can be pulled out of the mouth. When excising one half the surgeon splits the tongue down the middle by snipping the tip of the tongue between the two threads and then running the blade of the scissors along under the thick mucous membrane

of the dorsum and dividing it. With the shut scissors or finger the cellular septum in the middle line is opened up. The half to be excised is then pulled up towards the upper jaw on the opposite side of the mouth, and the mucous membrane of the floor of the mouth divided along its reflection on the lower jaw as far back as the anterior pillar of the fauces. The tongue is thoroughly freed from the anterior pillar of the fauces and pulled well out. The mucous membrane is now divided transversely across the dorsum of the tongue, far behind the growth. With small snips of the scissors the muscular tissue of the tongue is divided, beginning from the under surface and keeping close down to the hyoid bone. Any small arteries that may spurt are at once secured, the blood being sponged away with small sponges on long-handled sponge-holders. The lingual artery is met with near the middle line and nearer the inferior than the superior surface of the tongue ; it can often be seen and secured with forceps before division,. The lingual artery is ligatured or twisted, and any other bleeding point dealt with in the same way. Should there be any difficulty in securing the lingual, the index finger of the left hand should be passed into the upper part of the pharynx and the stump of the tongue hooked forwards. This manœuvre, while bringing the bleeding point nearer the surgeon, also arrests the hæmorrhage, by compressing the artery between the finger and the back of the hyoid bone. If the whole tongue has been removed a strong silk suture should be passed through the stump and brought out through the mouth and fastened to the cheek by strapping. This prevents the stump falling backwards and impeding respiration.

Comment.—When the whole tongue is to be removed it should be slit down the middle and one half taken away before the other. This has the advantage of allowing the surgeon to see more clearly what he is doing. In order to get enough room to work in the mouth a good gag is in most cases quite sufficient, the cheek on the affected side being retracted. If this is not sufficient, then the cheek must be split as far as the masseter, the line of the incision being planned to avoid division of the branches of the facial nerve. The incision is sutured accurately at the close of the operation. The excision must pass wide of the growth, even at the expense of structures other than the tongue, portions of the lower jaw and floor of the mouth sometimes requiring removal. In removing portions of the mandible a bridge of bone should, if possible, be left to maintain the contour of the jaw. If the growth encroaches on the floor of the mouth in front, the lower incisor teeth on that side

may be drawn, and free access thus obtained to the floor of the mouth.

(2) *Syme's Method*

Instruments.—In addition to those needed in the last operation a small saw and a pair of bone forceps, drills, and silver wire are necessary.

Operation.—A silk ligature is passed through the tip of the tongue to be used as a tractor. The lower lip is divided in the

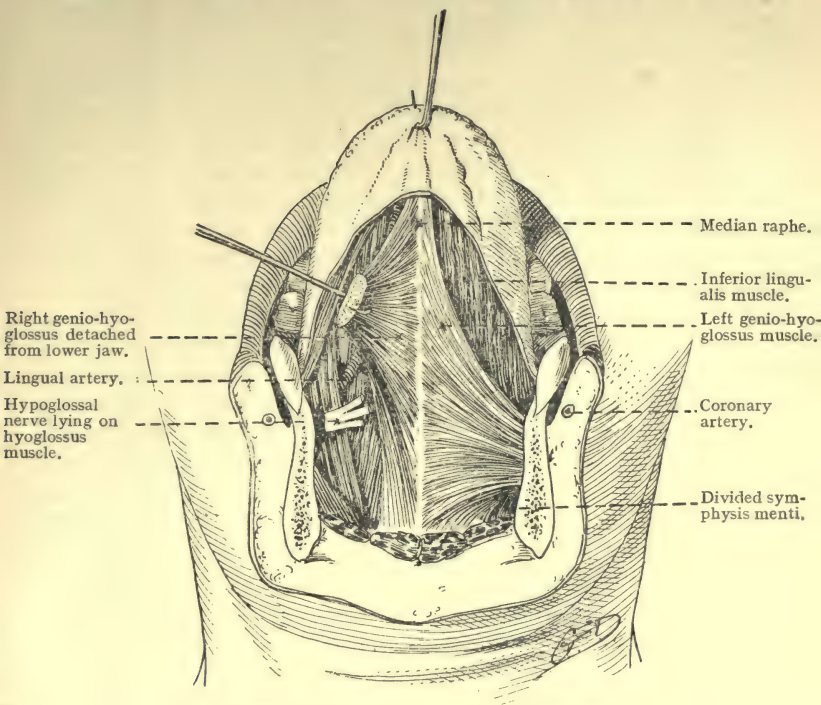


FIG. 90.—EXCISION OF THE TONGUE.
(*Rose and Carless.*)
The lower jaw has been divided in the middle line and retracted.

middle line, the small coronary arteries being caught on either side with forceps; the incision is carried down in the middle line as far down as the hyoid bone. The jaw is then drilled just below the sockets of the teeth, a little to one side of the middle line. With the saw, the mental protuberance is divided. As the bone in this situation is specially dense, it is as well to finish the section with forceps. The two halves of the jaw are now widely separated, and with the silk ligature the tongue is

drawn out of the mouth. The reflection of mucous membrane from the tongue on to the lower jaw is divided with scissors near the bone, and the tongue freed as far back as the anterior pillars of the fauces. The muscles of the tongue and floor of the mouth are thus exposed. On the surface of the hyoglossus muscle are seen the lingual vein, the lingual nerve passing along close under the mucous membrane of the side of the tongue, and the hypoglossal nerve lying below it. At the anterior end of the same muscle the lingual artery is found. The genio-hyoglossi and the genio-hyoids are next cut through and the tissues at the root of the tongue separated as far back as is necessary. The transverse section of the tongue is then made with the scissors, blunt-pointed bistoury, or cautery, care being taken to keep the incision in healthy tissue wide of the disease. If the lingual arteries have not already been ligatured in the operation they must be caught as soon as severed. No diseased tissue should remain. All bleeding points having been secured, the two halves of the jaw are brought into apposition and wire passed through the two drill holes and twisted up. The lip is accurately sutured and the wound below the chin closed, a tube being left above the hyoid bone for drainage.

Comment.—The chief disadvantage of this operation is its severity. Very good access is obtained by this method, especially for growths far back on the tongue, involving the pillars of the fauces, tonsils, or palate. In dividing the muscles of the floor of the mouth so freely, there is the danger of the stump falling back and impeding respiration ; a silk ligature should be used, as in the last operation, to prevent this happening. Kocher, to avoid this accident, divides the jaw in an oblique manner, so as to leave the muscles still attached to the genial tubercles, only dividing those on the side affected. By this means the action of deglutition is very little impaired.

After-treatment.—The patient should be propped up in bed as soon as he has recovered from the effects of the anæsthetic. The patient may be allowed to try and swallow fluids the same evening. This he is usually able to do, if only one half of the tongue is removed. When the whole tongue is excised, the patient may be fed with a feeding cup, to the spout of which is attached a rubber tube long enough to reach the back of the pharynx. The mouth should be washed out with some warm antiseptic fluid. This can be done without disturbing the patient by simply hanging the head over a basin and allowing the fluid to flow in from a douch-can, held slightly above the level of the head, the patient meanwhile breathing through the nose. A weak

solution of potassium permanganate or weak (1 in 80) carbolic may be used. The patient may be allowed to sit up in an easy-chair on the day after the operation, and should carry out the douching himself every two hours or so. If swallowing cannot be managed nutrient enemata must be given. They are seldom needed for more than thirty-six hours. It is important to get the patient up and about soon, and to feed him well.

ŒSOPHAGOTOMY

Indications.—The œsophagus is opened usually to enable the surgeon to extract foreign bodies which have been accidentally swallowed, such as tooth plates, or small metallic substances, which have resisted all attempts at removal made through the upper opening at the pharynx. The operation has been occasionally performed for the stretching of simple fibrous strictures, or to remove polypi situated in the upper part of the tube.

Anatomy.—The œsophagus begins at the level of the lower border of the cricoid cartilage opposite the sixth cervical vertebra, and is about ten inches in length. The tube lies behind the trachea, and slightly to the left of the middle line in the neck. In the angle between these two structures lies the recurrent laryngeal nerve, on either side, accompanied by the inferior thyroid artery. To the outer side lies the carotid sheath with its contents. In the upper portion of its course, the œsophagus is in relation to the lateral lobes of the thyroid body and the middle thyroid veins as they pass outwards to the internal jugular vein. Posteriorly are the prevertebral fascia, longus colli muscles, and vertebral column. The following points should be remembered in passing the œsophageal bougie. The distance from the incisor teeth in the adult to the commencement of the œsophagus is six inches ; to the point where it is crossed by the left bronchus, nine inches ; to the opening in the diaphragm, fifteen inches ; to the cardiac orifice of the stomach, sixteen inches. The tube is slightly constricted in three places, at its commencement opposite the cricoid, at the point where it is crossed by the left bronchus, and lastly where it passes through the diaphragm.

Instruments.—In addition to the ordinary instruments, a gag, œsophageal bougies, and long-bladed dressing forceps are required.

Position.—The patient lies in the dorsal position, with the head turned to the right and a sandbag under the neck. The surgeon stands on the left side with the assistant opposite him.

Operation.—This is always performed on the left side of the

neck as the œsophagus lies slightly to the left of the middle line. The operation may be divided into three stages :—(1) The exposure of the œsophagus ; (2) the removal of the foreign body ; (3) the treatment of the wound.

Stage 1. *Exposure of the Œsophagus.*—An incision is made about three or four inches long, beginning just above the sternal extremity of the clavicle and passing upwards along the anterior border of the sterno-mastoid muscle. The incision divides the skin, superficial and deep fascia, platysma, and exposes the anterior border of the sterno-mastoid muscle. The anterior border of this muscle is defined and the finger feels the position of the foreign body or the bougie in the œsophagus. The muscle, together with the carotid sheath, is then drawn outwards, exposing the infra hyoid muscles. The omo-hyoid muscle is pulled to one side or divided, the sterno-hyoid and sterno-thyroid muscles are pulled inwards. The trachea and thyroid body are only hidden now by the pretracheal layer of fascia. This fascia is divided in the long axis of the original wound. The trachea is now plainly seen on retracting the various structures already mentioned. At the bottom of the wound is the longus colli muscle ; between the longus colli muscle and the trachea a small portion of œsophagus is found. The inferior thyriod vessels and the recurrent laryngeal nerve lie in the angle between the thin edge of the œsophagus and the trachea, and must be avoided. If there is any difficulty about locating the position of the foreign body, a bougie should be passed by an assistant and the bulbous extremity felt by the surgeon's finger in the wound.

Stage 2. *The Removal of the Foreign Body.*—The position of the foreign body having been made out with certainty, the margin of the gullet is steadied by forceps while the edge is incised longitudinally. The foreign body is now carefully extracted with long curved dressing forceps. During the removal of the foreign body, which may take some little time, the gullet wall must be saved as much as possible from laceration and injury.

Stage 3. *Treatment of the Wound.*—If the foreign body has only recently become impacted in the œsophagus and has not had time to ulcerate into its wall, then it is best to close the wound in the tube at once. This should be done by first suturing the mucous membrane, and then closing the wound in the muscular wall ; small curved needles and a needle holder will be necessary for this. If the impacted body has been in position for some time, it has probably caused a good deal of injury to the wall of the œsophagus and may have ulcerated through ; it is then better not to attempt to unite the walls of the gullet but to pack the

wound with gauze. The external wound should only be partially closed in any case, free drainage being allowed for the escape of fluids which may force their way out during the efforts of vomiting or swallowing. The wound is allowed to granulate up from the bottom.

Œsophagostomy has been proposed for the relief of patients suffering from strictures high up in the œsophagus instead of performing gastrostomy. The steps of the operation are the same as in the last, only that the edges of the tube are sewn to the skin. The operation is hardly ever performed, as it has no advantages over gastrostomy, while its disadvantages are obvious.

ABDOMEN

Anatomy.—The general structure of the abdominal wall is so well known to every student that it is needless to dwell for any length of time on the various structures of which it is composed. The two recti occupy a position on either side of the middle line of the abdomen. Their inner margins are separated by the linea alba and the umbilicus, which is situated at a variable level. Their outer margins correspond to the linea semilunaris, which is marked out by a line curved slightly outwards, passing from the spine of the pubis to the tip of the ninth costal cartilage. The pyramidalis muscle is small and unimportant, often being absent altogether, but occasionally is large and reaches up to the umbilicus. The external oblique muscle is arranged with its fibres passing downwards and inwards, no muscular fibres passing below the level of the anterior superior spine of the ilium. The general direction of the fibres of the internal oblique is upwards and inwards, except that portion which lies below the level of the anterior superior spine of the ilium. Here the fibres have much the same direction as the fibres of the transversalis muscle. The general direction of the transversalis muscle is forwards and inwards towards the middle line except in the lower portion, where together with the lower fibres of the internal oblique, the muscle arches downwards to be inserted into the pubis. The special relations of the region will be dealt with in the chapter on inguinal hernia.

The arteries of the abdominal wall may be divided into three sets, those running forwards, those running downwards, and those running upwards. These three sets anastomose with one another freely, and slightly with those of the opposite side. The vessels running forwards are the lower two intercostals, the subcostal, and the lumbar arteries ; they lie in the same plane as the nerves

of the abdominal wall, *i.e.* between the transversalis muscle and the internal oblique. The artery running downwards is the superior epigastric, one of the two terminal branches of the internal mammary. It enters the abdominal wall by passing between the costal and sternal attachments of the diaphragm, and then runs down in the substance of the rectus muscle. The vessels running upwards are the deep epigastric and circumflex iliac vessels. The deep epigastric arises from the external iliac just above Poupart's ligament and runs upwards and inwards to the inner side of the internal abdominal ring and spermatic cord, to enter the sheath of the rectus by passing in front of the semilunar fold of Douglas. The line of the artery may be marked out by drawing a line from the mid point of Poupart's ligament to the umbilicus. The deep circumflex iliac artery comes off at the same level as the last and runs upwards and outwards behind Poupart's ligament and then along the crest of the ilium. Near the anterior superior spine of the ilium it sends upwards a large, constant, but unnamed branch between the internal oblique and the transversalis. The superficial epigastric and circumflex iliac arteries need not be specially mentioned.

In connection with the linea alba it should be remembered—(1) that it is better marked above than below the umbilicus, in the latter position the inner edges of the recti lie in contact with one another; (2) that its blood supply is scanty; (3) that the fascia transversalis is adherent above the umbilicus, while below it is separated by a considerable amount of fat, which may be mistaken for extra-peritoneal fatty tissue.

Preparation of the Patient.—This is the same as the preparation for any other operation, and if the precautions which should always be taken before performing any serious operation are conscientiously carried out, these should suffice for operations on the abdominal cavity as for operations elsewhere. In operations on the stomach that viscus should be washed out just previous to the administration of the anæsthetic. A stomach tube is passed, and a weak solution of potassium permanganate used to flush out the organ. The flushing should continue until the fluid is returned unchanged in colour. This not only clears out any obnoxious products which might possibly escape at the time of the operation, but it also diminishes the amount of sickness which occurs afterwards. The only contra-indication to washing out the stomach is in ruptured gastric ulcer; here the stomach should on no account be washed out. In œsophageal obstruction, of course, the proceeding cannot be carried out.

Site of Incisions.—The incisions which do least injury to the

abdominal wall are those situated in the linea alba ; no nerves, vessels, or muscular fibres being here cut. In many operations, however, it is more convenient to use other sites. Incisions placed elsewhere than the middle line should be so planned that they do little harm to the neuro-muscular mechanism of the abdominal wall. A vertical incision through the external oblique at some distance external to the linea semilunaris not only divides the muscular tissue, which will never subsequently be as strong again at this point, but it also severs the nerve supply of the

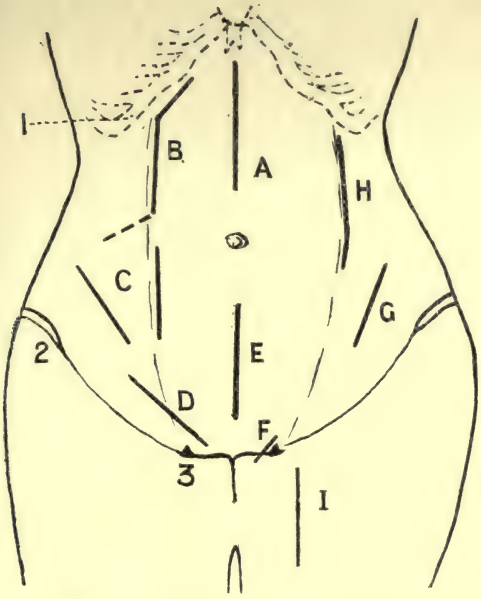


FIG. 91.—ABDOMINAL INCISIONS.

1, 9th costal cartilage. 2, Anterior superior spine. 3, Pubic spine. A, Gastric operations. B, Biliary tract. C, Two incisions to expose the appendix. D, Inguinal hernia. E, Operations on uterus or ovary. F, Varicocele. G, Inguinal colotomy. H, Transperitoneal exposure of kidney. I, Femoral hernia.

muscular fibres which are more mesially placed. With the nerve supply severed the muscular tissue atrophies and a weakness in the wall of the abdomen is caused. Especially is it important in the lower part of the abdomen that no weakness should be caused by the incision, as it is here that ventral herniæ are most likely to occur. Division of muscular fibres is therefore to be avoided, and access to the deeper parts obtained by splitting the muscle in the direction of its fibres. The nerves, if seen, are

pulled to one side. After the operation the slit in the muscle is closed by sutures. Some surgeons prefer making their incisions a little to one side of the middle line to opening through the linea alba. The sheath of the rectus is opened and the muscle drawn outwards, the posterior layer of the sheath is cut through and the peritoneum opened. When the wound is closed the posterior layer of the sheath is sewn up, the rectus replaced and the anterior layer of the sheath sutured. Here uninjured muscle guards the line of the incision (Fig. 95). The same procedure may be followed when opening in the region of the linea semilunaris. The anterior layer of the sheath is opened and the rectus drawn inwards, and the posterior layer of the sheath then divided. In this case, although the muscle itself is uninjured, unless care be taken its nerve supply may be severed, and atrophy of that part of the muscle ensue.

Method of Opening the Abdomen.—By whatever route the surgeon attempts to open the peritoneal cavity, certain points should be carefully attended to.

With the fingers and thumb of the left hand the skin of the abdomen is steadied while the incision is made. This should divide everything down to the external oblique or its aponeurosis. A considerable depth of fat is met with in children and adipose persons. The external oblique or its aponeurosis is split in the direction of its fibres for the whole length of the incision and the margins of the muscle well retracted. The same procedure is followed in dealing with the internal oblique and the transversalis muscles. If the original incision is made over the rectus, the anterior layer of the sheath is opened vertically, the muscle split in the direction of its fibres or pulled to one or other side without division, and the posterior layer of the sheath cut vertically. The operator should have recognized the different layers of tissue he has cut through, or he may now mistake the exposed fascia transversalis for the peritoneum, and the extra-peritoneal fat below it for the omentum. The transversalis fascia and the extra-peritoneal fat, which may be half an inch thick in stout people, are divided for the whole length of the wound. The peritoneum is now exposed. All bleeding points are secured before opening the peritoneum. The peritoneum is picked up with forceps and a small snick made in it close to the point of the forceps, the knife being held on the flat. Through the hole thus made, the point of the forceps is thrust and the peritoneum slit up between the blades until a large enough aperture is made to admit two fingers. Using the fingers as directors the peritoneum is opened for the whole length of the wound. Catch forceps are applied to the cut edges of the peritoneum for future

identification. By picking up the peritoneum with forceps in this way the danger of opening into adherent bowel is diminished.

Methods of Closing the Abdominal Wound.—The fear of a subsequent ventral hernia occurring at the site of operation must

FIG. 92.—MEDIAN INCISION THROUGH UPPER PART OF THE ABDOMEN CLOSED IN LAYERS.
Note the arrangement of rectus sheath.

FIG. 93.—MEDIAN INCISION THROUGH LOWER PART OF THE ABDOMEN CLOSED IN ONE LAYER.
Rectus sheath absent behind, the muscles lie in apposition.

FIG. 94.—AN INCISION MADE TO THE LEFT OF THE MIDDLE LINE, THE RECTUS MUSCLE SPLIT.
On the right side the wound is shown closed.

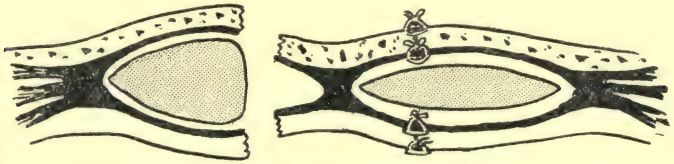


FIG. 95.—AN INCISION MADE TO THE LEFT OF THE MIDDLE LINE, THE RECTUS DRAWN OUTWARDS.
On the right the wound is shown closed, with the muscle intact, and ventral hernia impossible.

always be borne in mind. It therefore behoves the surgeon to pay great attention to the sutures applied to bring the edges of the abdominal wound together. The abdominal wall must be left as far as possible in the same condition as nature meant it to be. This is best done by bringing the different layers of the

wall together accurately. The peritoneum is stitched to peritoneum ; in the lower part of the abdomen the fascia transversalis is often included in this suture.

The edges of the muscles, if cut or split, are then sewn together, each layer, if necessary, being dealt with separately.

The aponeurosis, if present, is next united, and lastly the skin incision is closed. Very seldom in clean cases is a drainage tube inserted. In draining appendicitic abscesses a tube has to be left in. In this case the wound is closed accurately as far as the tube, which is not kept in longer than is absolutely necessary. If rapidity is essential it may be necessary to forego the suturing of each of the different layers separately, in which case the whole thickness of the walls may be brought together with stout silkworm gut. Many such sutures are passed and tied tightly. If everything is satisfactory they should be left in a full fortnight, to prevent stretching of the newly formed connective tissue.

METHODS OF SUTURING THE STOMACH AND INTESTINES

The great object of all methods of suturing the stomach and intestines is to produce a junction which will be absolutely watertight and will allow no leakage of the septic bowel contents into the abdominal cavity. Of the different coats of the intestine, the serous, muscular, submucous, and mucous, it is only to the first that we look for protection against leakage during the first few hours after suture.

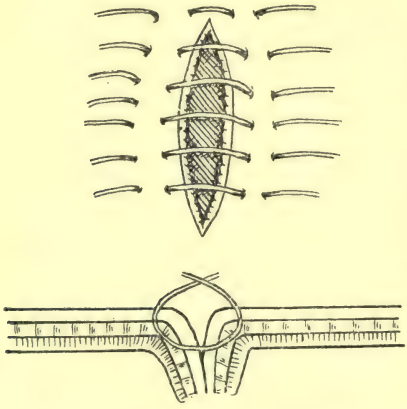


FIG. 96.—THE LEMBERT SUTURE.

The peritoneum rapidly unites with any raw surface, but especially will it unite to other peritoneum when the surfaces are fixed in close apposition.

All methods of suture have therefore as their object the bringing together of serous surfaces. The stitch which best brings this about is the Lembert suture, or some modification of it.

The Lembert Suture.—A needle threaded with fine silk is inserted a little way from the margin of the wound in the gut,

and made to pierce the serous and muscular coats and travel some way in the sub-mucous coat before emerging close to the margin of the wound. The needle is then carried over the wound and made to repeat the same performance on the opposite side, this time the needle being entered near the wound margin and emerging some little distance away. If now the stitch is tightened and tied, the result will be that the edges of the wound are inverted and the two surfaces of peritoneum are brought into close contact.

The original Lembert suture was an interrupted suture like the one just described, so that each one had to be knotted and

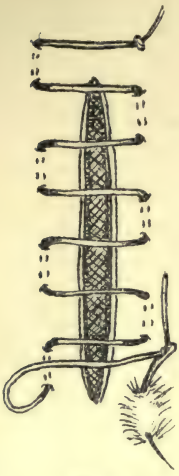


FIG. 97.—THE RIGHT ANGLED STITCH.

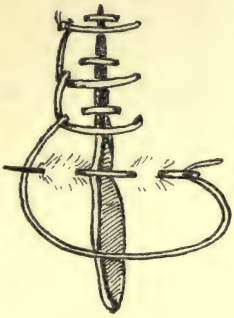


FIG. 98.—THE BLANKET STITCH.

FIG. 99.—THE SIMPLE OR GLOVER'S STITCH.

cut short. Much time is saved by retaining the method of passing the suture but using it in a continuous manner, either the oblique, the blanket, or the rectangular as preferred. Other forms of suture are sometimes used, but they have all the same principle.

Czerny's Suture.—This is a double row of sutures, the first row, which merely unites the mucous membrane, being inverted by the second, it may consist of interrupted or continuous sutures.

Gussenbauer's Suture.—This is a double Lembert, each stitch piercing the serous and muscular coats twice on each side of the wound in the gut. This suture takes longer and is more difficult to insert than the preceding.

The Quilted or Mattress Suture.—This suture is recommended and used by Professor Halstead. It is inserted according to the method shown in Fig. 101, the stitches only piercing the serous and muscular coats.

There are a great number of other methods described which need not be mentioned here.

The usual procedure followed by most surgeons is to pass a suture through the whole thickness of the walls on both sides of the wound so as to unite these together and bring the mucous membrane in apposition. This suture is continuous and serves

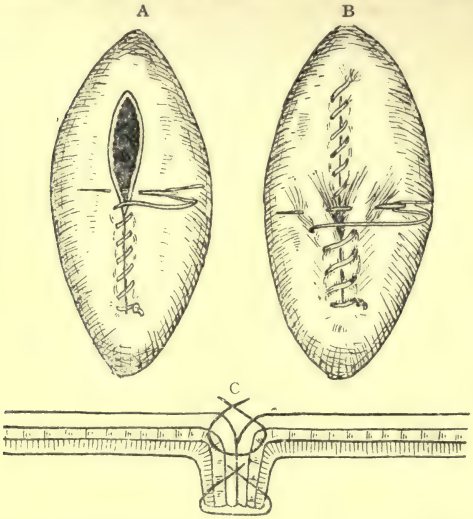


FIG. 100.—CLOSING AN OPENING IN THE INTESTINE.

A, The 1st row, with sutures piercing all coats. B, 2nd row, Lembert sutures burying the 1st row. C, Diagram of the result.

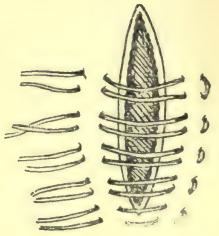


FIG. 101.—QUILTED OR MATTRESS SUTURE USED BY HALSTEAD.

to close the wound in the gut. A row of Lembert sutures is now inserted, usually in a continuous manner so as to bury the first row of sutures. An additional stitch may be applied anywhere it is thought that the suture line is weak.

In class work it is convenient for the students to work together in pairs, taking it in turn to act as assistant.

A quantity of the small intestine of the pig should be obtained; this being slightly larger and thicker than human intestine, forms a very suitable material on which to practise. When the correct methods have been learned, and a certain amount of facility acquired, fresh human intestine can be used with

advantage. The shrivelled condition of the intestine from bodies injected with formalin renders it useless for this purpose.

Instruments.—The instruments required for all abdominal operations are—scalpel, scissors, artery and dissecting forceps, intestinal clamps, abdominal retractors, needles (both skin and straight and curved intestinal), ligature and suture material.

The best form of intestinal clamps are long catch forceps with broad curved blades, which can be closed without exerting too much pressure; if they are so powerful as to need indiarubber tubing on the blades to protect the intestine they should be discarded and some with a weaker spring obtained. They may be curved or straight, according to fancy. Large, and often unnecessarily cumbrous ones are used in connection with the stomach.

Needles for intestinal work should be round, and unprovided with cutting edges near the point.

Straight needles are infinitely preferable to curved, but in some cases the latter must be used, and therefore it is a good plan to practise with both forms. The needles should be as fine as is consistent with ease in threading, but length is of value if the sewing is to be done by hand. For class work, ordinary darning needles, of the size No. 5 or 6, will be found excellent. In sewing, if guides are used in the way described below, the assistant should hold the gut in such a way that the surgeon finds that he is always sewing along a straight line, a method which is infinitely superior to all forms of bobbins and artificial supports. The assistant should hold the guide so that the suture line points directly away from the surgeon, who can then use both hands in the following way. With the left he holds the thread of the last stitch and so steadies the suture line, while with his right he passes the needle through both pieces of bowel, the point is drawn through by the left hand and the needle passed to the right for the next thrust. Facility in passing the needle to the right depth through the bowel wall is easily acquired.

Swabs of various shapes and sizes are used by different surgeons according to fancy, but when the abdominal cavity is opened, care must be exercised to avoid leaving swabs among the coils of intestine. Many instances of this accident could be quoted. Nothing is safer than the use of long rolls of gauze, which cannot be overlooked, or large squares of absorbent material or swabs, to the projecting tail of which an artery forceps can be attached. Nothing is more risky than the use of the ordinary small swabs, which are in general use for other wounds. If swabs in any form

are used, some one should be responsible for their number before and after the operation.

Before passing to operations on individual parts of the alimentary tract contained in the abdomen, it is first convenient to describe the technique of procedures which are applicable to the whole length of the intestinal canal.

The small intestine has therefore been selected as the portion best adapted to illustrate these procedures. Nearly all the points common to abdominal operations, and the broad principles followed in performing them, are to be found in this chapter. The same technique will be found again and again repeated in operations on special parts of the intestine.

The following will be described :—

I. Resection of a portion of Intestine with the various Methods of dealing with the two pieces of Gut—

A. By Suture :

(1) End-to-end anastomosis.
  (*a*) Ordinary method.
  (*b*) Maunsell's method.

(2) Lateral anastomosis (side to side).
  (*a*) Ordinary method.
  (*b*) Halstead's method.

(3) Lateral implantation (end to side).

B. By Mechanical Means :

(1) Murphy's button.
(2) Bobbins.

C. Formation of an Artificial Anus.

II. Enterostomy.

III. Closure of a fæcal fistula.

I. Resection of a portion of Intestine with the various Methods of dealing with two pieces of Gut.

Resection of a portion of the small intestine is termed enterectomy, of the large intestine colectomy.

Indications.—1. Injuries where the gut wall has been extensively devitalized, destroyed, or wounded.

2. Stricture, either the simple fibrous stricture, which is rare and mostly found in the small intestine, or the more common malignant stricture, which is usually primarily in the colon and invades the small intestine at a later date.

3. Gangrene of the intestine due, it may be, to one of the forms of hernia, or to a band causing strangulation within the abdominal cavity.

4. Intussusception, where the reduction of parts cannot be effected.

5. Volvulus, which cannot be untwisted on account of the adhesions and matting of the parts.

6. Fistulæ only occasionally call for such a severe method, as they are usually amenable to a less radical procedure.

7. Tubercle, when affecting a localized part of the intestine, such as the cæcum.

8. Polypi, when they give rise to symptoms or are the cause of intussusceptions.

Operation.—An incision is made and the peritoneal cavity opened in the usual manner. The parietal peritoneum is secured for future identification with a pair of artery forceps on each side of the wound. The fingers are inserted and the portion of the gut which requires removal is brought up out of the abdominal cavity. In many cases adhesions will have to be dealt with to allow this to be done, but if possible the bowel should be drawn out of the wound, as thereby the subsequent manipulations are much simplified. The general peritoneum is carefully packed off with gauze.

The intestine is doubly clamped on each side of the portion to be resected, and the mesentery clamped and divided parallel to the long axis of the gut, or if diseased a triangular portion may be removed. The bleeding points in the mesentery are at once secured. The gut is then cut across between each pair of clamps. The next step is to re-establish continuity between the two portions of intestine.

A. By Suture

(1) *End-to-end Anastomosis*

(*a*) **Ordinary Method.**—The clamps may be removed, the assistant holding the two pieces of intestine in apposition in such a manner as to prevent leakage, or the clamps may be moved further from the site of suture. The surgeon inserts three supporting sutures which unite the whole thickness of the intestinal walls. These sutures are tied and the ends left long with forceps attached to them, and serve as guides for the rest of the operation. The first of these sutures, A, is inserted at the mesenteric attachment of the gut, the other two are inserted so as to divide the circumference of the intestine into thirds.

Two of these guides, A and B, are held taut by the assistant while the surgeon rapidly passes the first row of sutures through the whole thickness of the intestinal walls, uniting the third of the intestine between A and B. The thread is now knotted to B, and if too short to be used again is cut short. A fresh thread is taken (the former thread can be used if long enough), and the segment between B and C united in the same way, the thread ended by being knotted to C. The last third of the circumference of the gut is dealt with in exactly the same manner, the thread ending at A. In this way the whole of the circumference of the two portions has been united by suture, which has passed through the whole thickness of the gut wall. The next row of sutures

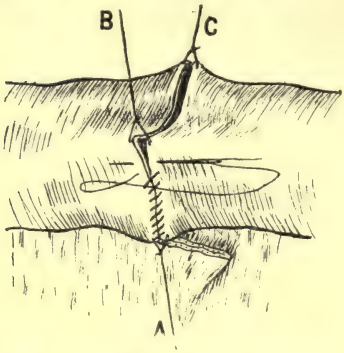


FIG. 102.—END-TO-END ANASTOMOSIS.

Guide sutures A, B and C; first row commenced, A to B.

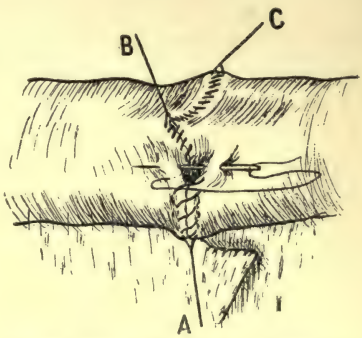


FIG. 103.—END-TO-END ANASTOMOSIS.

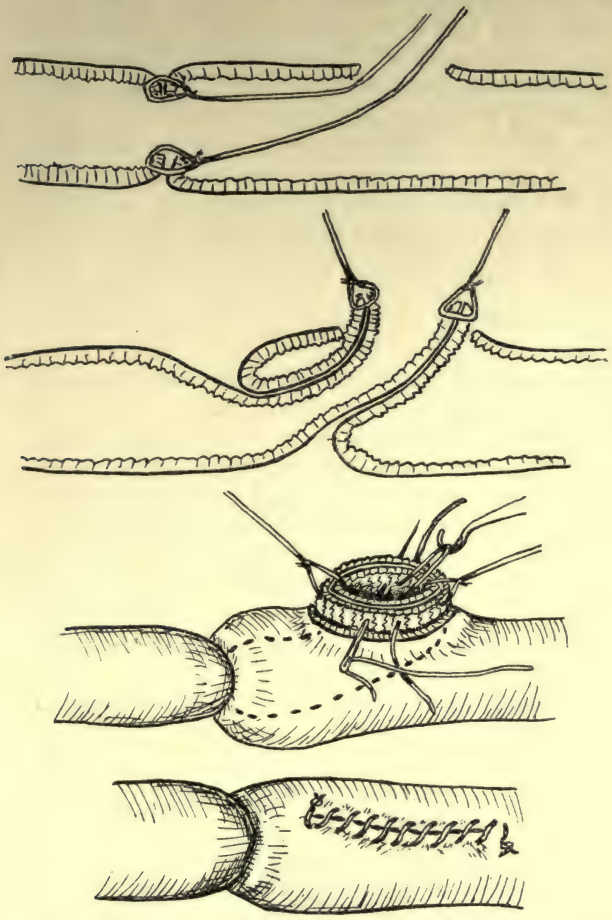
Guide sutures, A, B and C; second row commenced inverting first row; mesentery stitched up.

is inserted so as to bury the first row, the needle piercing only the serous and muscular coats.

The supporting sutures A and B are again held taut and a continuous line of Lembert sutures is run along this segment of gut, completely inverting the edges united by the first row, the thread ending at B. The segments B to C and C to A are dealt with in the same way. Thus the lumen of the gut is re-established and surrounded by two rows of sutures, the second of which inverts the first. A separate Lembert suture is inserted so as to bury the site of each supporting suture or guide, which is then cut short before tying the knot. Special attention is always paid to the area of mesenteric attachment to the gut.

If a triangular piece of mesentery has been removed the edges are united; if the mesentery has been cut square it is folded over and secured with stitches.

This method has the advantage that the suturing always takes place along a straight and steady line, which allows great rapidity of action. A very reliable and water-tight junction is thereby obtained in a minimum of time. The student is strongly advised



FIGS. 104–107.—DIFFERENT STAGES OF END-TO-END ANASTOMOSIS: MAUNSELL'S METHOD.

to practise this method either on pig's gut or on intestine obtained from the dead-house or dissecting room. Very little practice is required to familiarize him with the method.

(*b*) **Maunsell's Method.**—Two threads passing through the whole thickness of the gut are made to unite the two portions of

bowel together, one thread being inserted at the free margin and the other at the mesenteric attachment. These two threads are used to invaginate the two portions in the following way. An incision about three-quarters of an inch long is made in the free margin of the proximal portion of gut, about two inches from the cut end. The two threads are passed up to and out of this opening. Traction on the threads and manipulation will cause invagination of the distal and smaller into the proximal and larger portion of the two pieces of bowel. The threads then pull both ends out through the lateral opening, and are used to steady the parts while the sutures are being passed. The sutures are passed with a long, straight needle which pierces the whole thickness of the two adjacent walls on one side, passes across the lumen and pierces the whole thickness of the two adjacent walls on the other side. The thread across the lumen is hooked up and cut so that two sutures are formed, one passing through each pair of adjacent walls; these are at once tied. The needle is passed again and again; thus with ten passes of the needle twenty sutures can be placed in position. When a sufficient number have been inserted and tied, the ends of the long threads are cut short and the invagination reduced by gently pulling on the two portions of gut. The lateral wound in the proximal portion is closed with a row of Lembert sutures. The cut margin of the mesentery is then dealt with and the anastomosis is complete. In placing the threads in position it is advisable to pass the needle a good quarter of an inch below the cut margins of the gut so as to make sure of transfixing the serous coat, which is often hidden by the everted mucous membrane. Though this is the only row of sutures in Maunsell's original method, most surgeons prefer to bury the suture line with a row of Lembert sutures after the invagination has been reduced. This method is satisfactory and reliable, but is not quite so easy to perform as the last.

(2) *Lateral Anastomosis*

In lateral anastomosis before re-establishing the continuity of the lumen of the bowel, it is necessary to close up the two free ends. This can be done in a variety of ways. The ends of the gut still held in the clamp can be closed by a continuous suture passing through the whole thickness of the walls. The clamp can then be removed and the first line of sutures buried by a second row, consisting of Lembert sutures; both ends of the gut being treated in the same way.

Another and simpler method is to crush the end of the gut

in forceps and then to tie a ligature round the crushed portion, as the forceps are removed. The free portion of the gut is cut short close to the ligature. A purse-string suture is then run round the bowel, half an inch from the ligature, and the stump

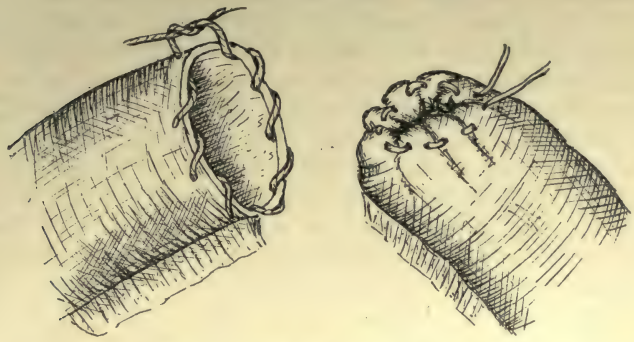


FIG. 108.—CLOSING THE FREE END OF THE GUT BY TWO PURSE-STRING SUTURES.

is inverted, buried, and the ligature cut short as the purse-string is pulled tight.

The ends being closed the two pieces of intestine should, if

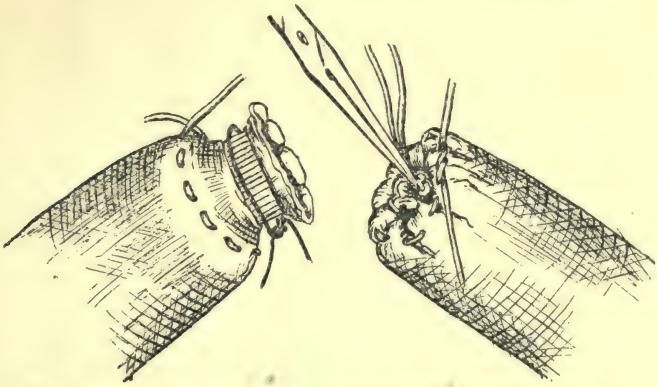


FIG. 109.—CRUSHING AND LIGATURING BEFORE INVERTING THE FREE END OF THE GUT.

possible, be laid together in such a manner that the direction of the peristaltic wave of the one corresponds with the direction of the peristaltic wave in the other. This position is termed iso-peristaltic. If the position is such that the wave in one is in the opposite direction to the wave in the other, it is termed

antiperistaltic. The iso-peristaltic position promotes the easier flow of intestinal contents and is therefore the one to choose.

(*a*) **The Ordinary Method of Lateral Anastomosis.**—In this method there are two guides and four rows of sutures. The two pieces of gut are laid together and their free margins united by two sutures placed about three inches apart. These sutures are left long and are held by an assistant so as to keep the suture line taut. The first row of continuous Lembert sutures unites the free borders of the two pieces of intestine together, passing from one guide along to the other. This suture pierces the serous and muscular coats only, the end being knotted off to the guide where it ends, and the thread may be cut short or laid aside to be used again. With a knife or sharp-pointed pair of scissors incisions about two and a half inches long are made opposite to

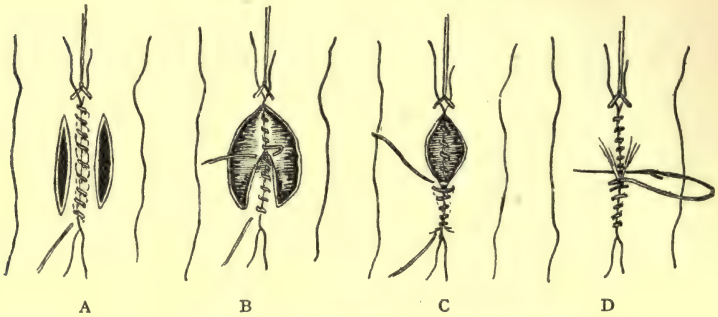


FIG. 110.—LATERAL ANASTOMOSIS.

A, 1st row, Lembert. B, 2nd row, through all coats. C, 3rd row, through all coats. E, 4th row, Lembert.

each other in each piece of bowel, about a quarter of an inch from the first row of sutures. These incisions should not extend quite to the end of the suture line. The second suture line unites together the two inner margins of these incisions by passing through the whole thickness of their walls. The suture commences at the extreme end of the incision by passing the needle from the lumen of one piece of bowel first through one wall and then through the other, to emerge in the lumen of the other piece of bowel. When the ends of the suture are knotted together the knot will lie on the mucous surface. This suture is run along the whole length of the cut surfaces. When the stitch has been inserted about half-way along its course, it should be locked by a half-hitch to prevent it drawing up like a purse-string.

The third row of sutures is really a continuation of the second

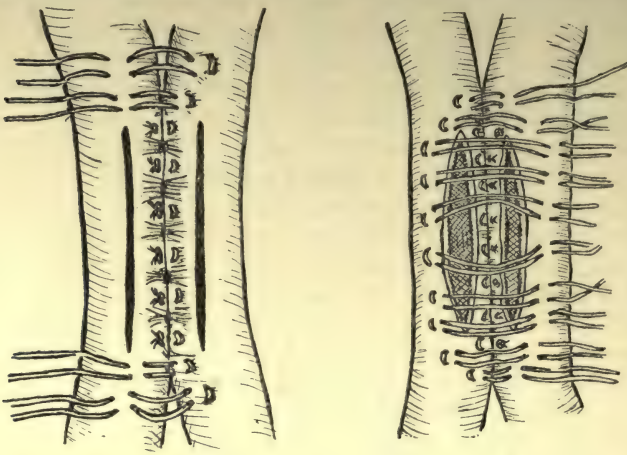
row, and the same thread may be used, or if this is not long enough a fresh one is taken. It unites the two outer cut edges in the same way that the adjacent edges were united by the second row. It is inserted by continuing the second row of sutures round the ends of the incisions from one side to the other. The student will find this rather difficult at first, but if he will continue to pass the needle in at the mucous surface of one piece and out at the mucous surface of the other until he is well round the corner, he will quickly solve the difficulty. When the corner has been turned, it is more convenient often to reverse the process and pass the needle in at the peritoneal surface of one piece of bowel and out at the peritoneal surface of the other. The suture line can be held up after each stitch is inserted so that both pieces of bowel can easily be transfixed with one thrust of the needle. By this third suture line the opening in the bowel is completely closed. The fourth suture line is made with a new thread, or with the needle and thread which was laid aside after completing the first line. It is made to invert the third line of sutures. Thus the two pieces of intestine are firmly united together, the lumen re-established and surrounded by two complete rings of sutures. The second and third rows of sutures pass through the whole thickness of the wall, while the first and fourth are Lembert sutures burying the other rows; any weak spot in the suture line can now be reinforced with an extra stitch. The two guide sutures are then cut short and the bowel returned to the abdomen.

(*b*) **Halstead's Method of Lateral Anastomosis.**—Here only one row of sutures is used to surround the opening. The sutures are all of the quilted or mattress variety, and only pierce the serous and muscular coats. All the sutures are placed in position before the two portions of the gut are opened, there is therefore little risk of leakage from the interior of the bowel. (*See* Fig. 111.)

The two pieces of gut are laid with their mesenteric borders in apposition. The first row of six quilted sutures is inserted close to the mesenteric border, tied, and cut short. The sutures are about a quarter of an inch apart. Three terminal sutures are now placed *en echelon* to close each end of the openings about to be made in the intestine.

A second row of six quilted sutures is now passed through the free borders of the portions of gut opposite the ones already tied. The ends of the second row are, however, not tied but are secured by forceps. The sutures are drawn aside while each piece of intestine is opened with a sharp-pointed pair of scissors between

the two rows of sutures. The second row of sutures, together with the terminal ones, are at once tied and the anastomosis is complete. This method is very rapid, and if the needles are all ready threaded beforehand, the actual anastomosis can be com-



A B

FIG. 111.—LATERAL ANASTOMOSIS: HALSTEAD'S METHOD.

A, One row of six sutures tied, two end sutures untied. The incisions are not made till all the sutures are in place.
B, Openings made, sutures ready to be tied.

pleted in three to five minutes. The drawback is that the anastomotic opening is very small, an inch and a half at most. As this method only has one line of sutures, leakage can nearly always be obtained when the anastomosis is tested under the tap in the dissecting room.

(3) *Lateral Implantation* (Fig. 112)

This procedure is made use of when there is great disparity in the size of the lumen of the two portions of intestine to be joined together. Instead of, as in lateral anastomosis, closing both ends of the gut, only the larger end is thus closed; the smaller portion is implanted into the side of the larger in much the same way as the small intestine is attached to the large at the ileo-cæcal junction. The method is used in joining the duodenum to the stomach after pylorectomy, in attaching the jejunum to the stomach in gastro-jejunostomy "en Y," and occasionally after enterectomy.

The end of the larger portion of gut is closed in one of the

ways already described (page 247). The end of the smaller portion, still clamped, is laid in apposition with the free border of the large piece of intestine. The anastomosis is brought about much in the same way as lateral anastomosis by four rows of sutures. Guide sutures, passed through the mesenteric and the free borders of the smaller portion and then through the adjacent part of the larger portion of gut, serve to fix the two in apposition, and to steady the parts for the passage of the sutures.

The first needle lays the first row, piercing the serous and muscular coats only, uniting the free margin of the larger with the posterior wall of the smaller piece of gut, about a quarter of an inch from its open end. (*See* Fig. 112.) When the whole breadth of the wall of the smaller piece is fixed the suture

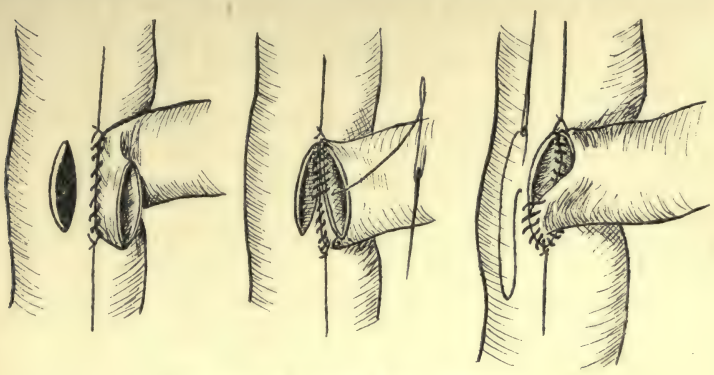


FIG. 112.—LATERAL IMPLANTATION.

is knotted to the guide thread and laid aside, but not cut short, as it is to be used again for the fourth row.

An incision is now made into the larger portion of bowel corresponding in size and position to the lumen of the smaller piece. If necessary a clamp is applied to prevent leakage.

The second needle inserts the second and third rows, piercing the whole thickness of the walls of the intestine. It unites the two adjacent edges of the two portions of bowel, and when the suture reaches the end of the incision and the second row is complete, it is then continued round so as to unite the two outer cut edges by the third row, and is finished off at its starting point. During its course this suture should be knotted in two or three places to prevent its being pulled tight like a noose round the opening.

The needle and thread used for the first suture are again taken up and made to insert the fourth and last row, inverting

the line of sutures which have united the outer cut edges of the intestine.

The two supporting sutures are cut short and the edges of the mesentery stitched.

Though the result is different the actual manipulations carried out differ very little from those in lateral anastomosis.

B. By Mechanical Means

In describing the various mechanical contrivances and the methods of using them, it must be remembered that such can never altogether replace the use of the suture. Knowledge of the technique of anastomosis by suture is of prime importance. Mechanical anastomosis is useful sometimes, but is wholly inadmissible at others. The fact that the instruments are not always to hand is sufficient to debar anyone from relying solely on their use.

The mechanical instruments in question may be divided into two classes, those which do away altogether with the use of the suture and of themselves re-establish the continuity of the bowel, and those which are merely supposed to render the process of suturing easier to perform. Of the former class Murphy's button, of the latter Robson's bobbin are the best examples. Many inventions, such as Laplace's forceps and Senn's plates, etc., have not fulfilled the hopes of their inventors, and are already things of the past.

(1) **Murphy's Button.**—This is the most ingenious mechanical contrivance yet invented to replace the suture. The button consists of a male and a female half. The male half has a spring flange by which the pressure is regulated, it is also supplied with the catch which fixes the two halves together. The female half receives the shank of the male half, and is furnished with a screw into which the catch on the male portion fits, holding the two together. The method of using the button is as follows :—

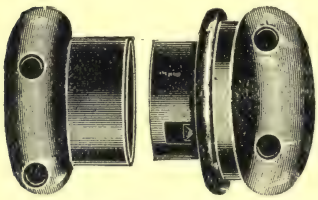


FIG. 113.—MURPHY'S BUTTON.

End-to-end Anastomosis.—An in-and-out purse-string suture is passed round the lumen of each piece of intestine, transfixing the whole thickness of the wall. This suture commences at the free margin of the bowel, and passing round to the mesenteric attachment is made to transfix and close the space between the

two layers of the mesentery in the way shown in Fig. 114, A, the suture is then continued round to the starting point. The two halves of the button, are placed in the ends of the bowel, and the sutures pulled tight and tied. The male and heavier of the two halves is placed in the distal end of the gut if this can be recognized, and care taken that in drawing the end of the suture tight the margins of the gut are infolded *over* the spring flange, which should not be seen at all when this half is in position. When both halves are in place, the shank of the male is passed inside that of the female and the two pressed together. The cut edges of the mesentery are united together, and the parts returned to the abdominal cavity.

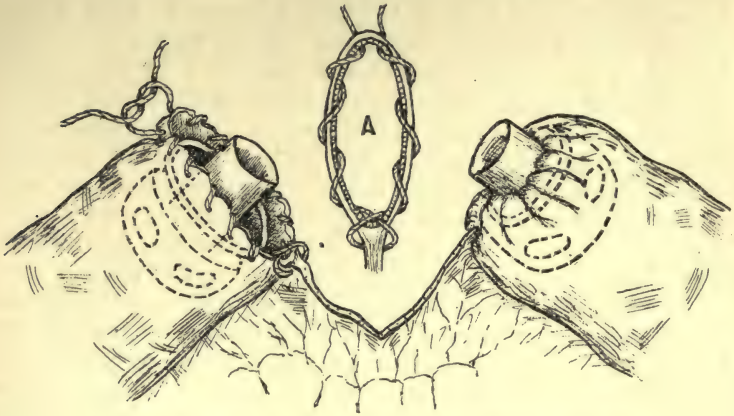


FIG. 114.—METHOD OF APPLYING MURPHY'S BUTTON.

A, Purse-string suture, showing the loop stitch by which the two layers of the mesentery are closed.

Lateral Anastomosis.—Here the procedure is rather simpler. A purse-string suture is passed in the side of each piece of intestine. The portion of bowel enclosed by the suture is opened and the half button is slipped in and fixed by drawing the suture tight. The suture serves to arrest the hæmorrhage as well as to fix the button. The same precautions for covering the spring flange of the male half must be taken as were described in end-to-end anastomosis. Both halves being fixed, the male portion is introduced into the female, and the junction is complete.

Lateral Implantation.—Here a combination of the two methods is employed. One half is fixed in the free end of the smaller piece of bowel, as if for end-to-end union ; the other is placed in the side of the larger piece of bowel, as if for lateral

anastomosis. When both are in place the two halves are pressed together.

If preferred a few Lembert sutures may be passed uniting the margins of the junction more securely after the button is in place, or the mesentery may be used to secure the junction. Between the halves of the button two broad surfaces of peritoneum are kept in contact with one another and adhere in consequence. Those portions of the intestine which are in the grip of the button eventually slough, and the button, thus freed, passes down the intestine, to be expelled per anum.

The advantage of the instrument is the rapidity with which union can be brought about. The disadvantages are (1) the opening, which is small to begin with, is liable to contract and become inadequate; (2) if too large a button be used, it may slough through the intestinal wall; (3) the button may lodge in the gut lower down and cause obstruction; (4) kinking and strangulation may be caused by the weight of the button; (5) in operations of the stomach only a very small instrument can be used, as a large one cannot pass through the small intestine. A small instrument is liable to fall back into the stomach and may necessitate an operation for its subsequent removal; (6) if, after the two portions of the button are fitted together, any mistake is detected, the instrument cannot be undone, and the gut must be resected to recover and separate them. The guide to the size of the button is the lumen of the distal portion of the gut, the largest button which fits into this easily is the one to be used.

(2) **Bobbins.**—Of these little need be said; they were usually made of decalcified bone of different sizes and were used to steady the suture line, and were supposed to facilitate sewing, which was otherwise carried out in the usual way. The decalcified bone being readily absorbed had none of the disadvantages enumerated in connection with the metal instrument. They are, however, little used as they are in every way inferior to the method of suturing as here described.

Methods of Anastomosing Portions of Intestine of different size

If the difference in size is slight, no inconvenience may arise and the ordinary end-to-end suture can be performed. But in such cases as excision of a chronic stricture where the lumen above has become ballooned while that below the stricture has shrunk, the difference is very marked. Here, by resorting to Wehr's or the oblique method of dealing with the smaller piece, an end-to-end anastomosis can still be brought about. To do

this, the smaller portion is cut across in an oblique manner so that more is removed from the free than from the mesenteric border. The extent of the two cut surfaces can thus be equalized without interfering with the blood supply of the free border of the smaller of the two portions. An ordinary end-to-end anastomosis can then join the two pieces together.

In other cases, where the difference in size of the two portions

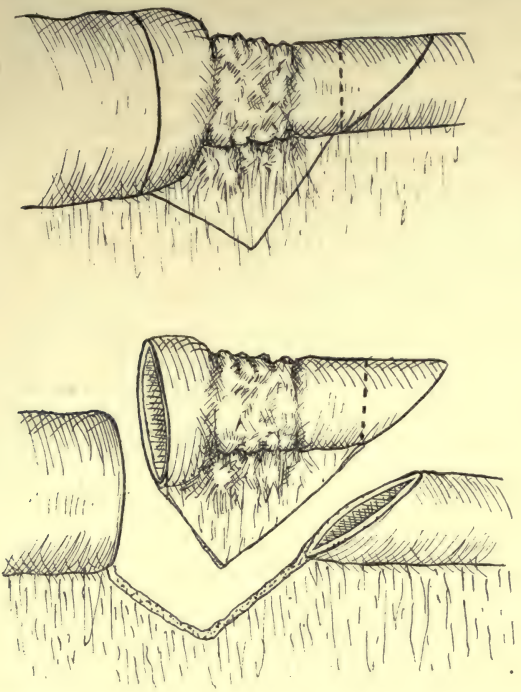


FIG. 115.—WEHR'S METHOD OF EXCISION, SHOWING METHOD OF DIVIDING GUT BELOW A STRICTURE, SO THAT THE LUMEN APPROACHES IN SIZE THAT OF THE HYPERTROPHIED PORTION ABOVE, AND END-TO-END ANASTOMOSIS CAN BE PERFORMED.

is still more marked, it is best to give up attempting an end-to-end anastomosis, for if a portion of the larger lumen is closed until the openings are about equal in size, and then an end-to-end anastomosis is performed, leakage is very liable to occur where the two suture lines join. It is better therefore to close the larger end completely and perform lateral implantation, or to close both ends and anastomose the two portions laterally.

C. Formation of an Artificial Anus

In cases where the condition of the patient is so bad that the operation must be finished as soon as possible after the enterectomy has been performed, it is sometimes unwise to attempt the union of the two pieces of gut; the surgeon must in these cases content himself with forming an artificial anus and leave the anastomosis till a later date. If the affected bowel can be brought out of the wound, the gut is fixed to the abdominal wall before the resection takes place. In other cases the resection has to be performed first and then the clamped ends of the intestine pulled out through the abdominal wall. One part of the wall is then closed, and the two pieces of intestine are fixed to the other part with sutures which pass through a portion of the abdominal wall and the parietal peritoneum on the one hand, and through the serous and muscular coats of the gut on the other. The two adjacent walls of the gut are sutured together to prevent the intestinal contents finding their way down into the abdominal cavity between them. A Paul's tube is then fixed with a piece of tape or a purse-string suture into the upper end of the gut, or if preferred a tube may be similarly fixed in both the upper and the lower ends, so as to carry away all the foul discharges from the region of the wound. Some surgeons recommend that in place of Paul's tubes the gut be simply fixed to the abdominal wall by sutures which pierce the whole thickness of the abdominal wall and then the whole thickness of the intestine.

II. Enterostomy

Enterostomy is the opening of the small intestine so as to allow a free exit for its contents. The opening is usually of a temporary character to relieve the symptoms of acute obstruction, when either the patient is unable to stand a more severe operation or where there are no facilities for performing one, or where the obstruction when found cannot be removed. In the last case it is sometimes better to perform a lateral anastomosis short circuiting the gut, but even this procedure has to be postponed occasionally. The procedure is sometimes known as Nelaton's operation, and when performed in the manner described below is pre-Listerian in technique, as no attempt at exploration is made.

Operation.—An incision two inches long is made, about two inches above the outer half of Poupart's ligament on the right side. The layers of the abdominal wall are carefully divided and the peritoneum opened. The first distended coil of small

intestine which presents is seized and drawn gently into the wound. A continuous suture is rapidly run round uniting the fascia transversalis and the parietal peritoneum to the serous and muscular coats of this coil, care being taken not to perforate the gut. In this way the peritoneal cavity is completely shut off before the bowel is opened. The intestine is opened by plunging into it a fine knife. The escape of gas and fluid at once demonstrates that the mucous membrane has been divided and not merely pushed forward by the knife. A short rubber tube may be fixed in to carry the escaping fluid away from the wound, or the bowel may be allowed to discharge into the dressings, which are frequently changed.

Comment.—The operation is not often performed, as it does not remove, nor does it gain information as to the cause. The obstruction has to be dealt with later, either by excision or short circuiting, and the fæcal fistula then has to be closed. There is no guarantee that the coil opened is not high above the site of obstruction and that evacuation will not, in consequence, be incomplete.

III. Closure of a Fæcal Fistula

The condition of fæcal fistula may range from a small opening allowing the escape of a few drops of yellow fluid through all gradations up to a large artificial anus through which the greater part or the whole of the intestinal contents are evacuated. The difference between a fæcal fistula and an artificial anus is that in the former some of the bowel contents pass on, in the latter all are discharged through the opening. The skin round the opening is probably eczematous and inflamed owing to the irritating nature of the discharge; this is especially the case when fluid from the upper part of the intestinal canal escapes, as at this level the digestive juices are still active.

Attention must be paid to render the condition of the skin as satisfactory as possible before operation. The amount of discharge varies with the size and length of the fistula, and on the relative position of the two portions of gut. If the opening is small only fluids will pass out, as is usually the case in fistulæ following appendicitis. If the opening is large, solid as well as fluid material may travel through it, the amount depending mainly on the relative positions of the proximal and distal portions of gut. If the two portions are in the same straight line the contents will easily pass along the natural way and little will escape by the fistula. If, on the other hand, the two portions are bent at an acute angle, a spur of bowel wall is formed which

guides the material out through the fistula and tends to shut off the lumen of the distal portion. As a result the lumen of the gut below the opening diminishes in size and the bowel atrophies, while more and more passes out through the fistula.

The simpler form of fistula often closes of itself, especially if care is taken to destroy the mucous membrane which grows up into it from the intestine. The old rule in pre-antiseptic days was not to operate before one hundred days had elapsed, from the formation of the fistula. In the severer forms, as it is largely the spur which is at fault, several methods of dealing with it have been advocated. Sir Mitchell Banks advised the introduction of a short, wide piece of rubber tube, one end of which was passed into the proximal and the other into the distal piece of gut. The tube is fixed by a silk thread which passes out of the fistula. By this means the two portions of gut are brought into a straight line and the spur done away with by pressure. The fistula rapidly gets smaller and either closes of itself or is dealt with by operation in one of the ways presently described.

Dupuytren advocated a different procedure for the destruction of the spur. A special pair of forceps, called an entreotome, was introduced through the fistula, and one blade guided on each side of the spur. The blades of the forceps then grasped the spur and were tightened sufficiently by means of a screw to retain their hold. The screw was tightened up day by day till the part between the blades sloughed and then came away. In this way the whole of the spur was gradually destroyed. The peritoneal cavity was shut off by union between the two serous surfaces as the result of the local irritation. The spur being destroyed the fistula tended to close.

Before an attempt is made to close the fistula by operation, the irritated skin round about must be made as healthy and aseptic as possible. It should be protected from the intestinal juice, either by smearing it with ointment, painting it with a solution of india rubber, or sticking a thin sheet of india rubber on with hot water or ether. It is well to clear out the bowels by syringing through the fistula as well as by the ordinary methods. The simpler forms of fistulæ may be treated by excision, the severer forms by resection of a portion of gut together with the fistula.

A. Excision

(1) *Without Opening the Peritoneum.*—The granulations are scraped from the sinus, which is plugged and may be closed with a stitch. Two curved incisions are made to surround the opening.

The incision is deepened at the point furthest from the fistula until the peritoneum is exposed. The tissues are then separated from off the peritoneum for at least two inches all round. The skin and peritoneum with the bowel attached, is pulled forwards and the fistula cut across flush with the peritoneum. The opening left in the bowel is then closed with a row of sutures, which pierce the parietal peritoneum and the muscular layer of the gut wall, which is attached to it. The first row is inverted by a second row. The wound in the abdominal wall is closed in layers.

Though this method closes the fistula in a safe manner it has the disadvantage of anchoring the bowel still more firmly to the anterior abdominal wall.

(2) *Opening the Peritoneum.*—The fistula is cleaned, scraped and plugged. Two curved incisions are made to surround the opening and the small skin flaps dissected up and clamped together over

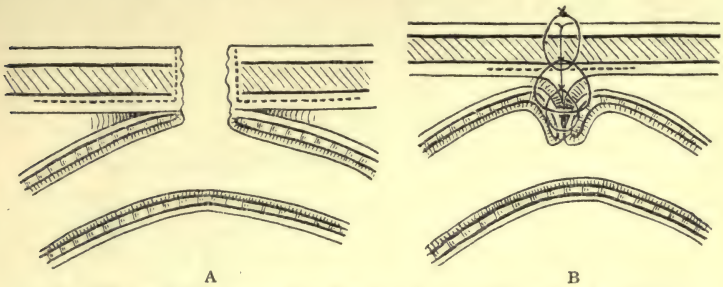


FIG. 116.—GRIEG SMITH'S METHOD OF CLOSING FÆCAL FISTULA WITHOUT OPENING THE PERITONEUM.

The dotted line in A marks the incision.

the opening. The incision is then deepened just wide of the scar tissue and the peritoneal cavity opened into very cautiously, as there are often many adhesions in the neighbourhood. If the fistula is not situated in the median line it is best to open the peritoneal cavity first on the inner side. When opened, the finger is put in and the extent and position of adhesions ascertained. The incision may then be carried through the peritoneum round the island of skin, the scar tissue containing the fistula, and the bowel into which the fistula leads, all of which are pulled up out of the wound. Adhesions are divided to enable this to be done. The bowel on each side of the opening is emptied of its contents by being passed through the fingers, and is then clamped. The peritoneal cavity is then shut off with gauze. A small elliptical incision is made in the long axis of the gut and the fistulous tract, with the skin and bowel openings, removed. The opening in the

bowel is closed in the ordinary way by two rows of sutures, the second inverting the first. If there is any fear of producing a stricture the incision in the gut may be sewn up at right angles to the long axis of the intestine. The gauze is removed, the bowel returned, and the abdominal wound sewn up.

B. Resection of a Piece of Gut together with the Fistula

It is rarely necessary to carry out this except in the case of large fistulæ, where nearly the whole of the contents of the bowel pass out through the opening. The fistula is dealt with and the abdomen opened in the same way as in the last operation.

The skin opening, the fistula, and the attached bowel, are pulled well out of the wound, and the general cavity of the peritoneum shut off with gauze. The bowel is clamped and cut through on each side of the fistula. The two ends are anastomosed in one of the ways already described. The bowel is then returned and the abdomen closed.

OPERATIONS ON THE STOMACH

Anatomy.—The stomach lies almost entirely in the left hypochondriac and the left half of the epigastric regions, only passing further than one inch into the right half of the latter region when distended. The cardiac orifice is situated four inches from the surface behind the seventh left costal cartilage, one inch from the middle line; it is about sixteen inches from the incisor teeth. The pyloric orifice is situated usually one inch to the right of the middle line when the viscus is partially distended and is overlapped by the anterior margin of the liver. When fully distended it may pass as much as three inches to the right of the middle line. The level of the pyloric orifice is best marked out by the transpyloric plane. This is the plane which corresponds to the mid-point of a line drawn from the supra sternal notch to the upper margin of the symphysis pubis, and is found in the majority of cases to pass through the centre of the pyloric aperture (Addison). In addition it lies three to four inches below the infra-sternal notch and opposite the body of the first lumbar vertebra. The anterior surface of the stomach is clothed by peritoneum, which forms part of the greater peritoneal sac; the posterior surface is covered by peritoneum, which forms part of the lesser peritoneal sac. Perforation of the anterior and posterior walls of the stomach by an ulcer will

therefore infect these sacs respectively. Normally there is a triangular portion of the anterior surface of the stomach in contact with the anterior abdominal wall; this area is bounded above and to the right by the anterior border of the liver, above and to the left by the costal margin, and below by a line drawn between the tips of the tenth costal cartilages. In certain cases, however, such as starvation from œsophageal obstruction, the stomach is drawn up entirely under cover of the liver. When greatly dilated it may reach Poupart's ligament. The posterior surface of the organ is only accessible after piercing the peritoneum of the lesser sac, either the gastro-colic omentum or the transverse meso-colon.

The blood supply of the stomach comes primarily from the cœliac axis; branches from the vessels into which that artery ultimately breaks up pass along the greater and lesser curvatures of the stomach and send branches at right angles to these curvatures over the surfaces of the organ. The actual vessels are the right and left gastro-epiploic arteries and the vasa brevia along the greater curvature, the coronary and pyloric arteries along the lesser curvature.

The following operations will be described :—

1. **Gastrostomy.**
   (*a*) Witzel's operation.
   (*b*) Kader's operation.
   (*c*) Frank's operation.
2. **Gastrotomy.**
3. **Operations for simple stricture of the pylorus.**
   (*a*) Pyloroplasty (Heineke and Miculicz).
   (*b*) Gastro-enterostomy.
4. **Relief of hour-glass contraction.**
5. **Pylorectomy.**
6. **Gastro-enterostomy, and jejunostomy.**
7. **Operation for perforated gastric ulcer.**

1. Gastrostomy.

Indications.—This operation consists in making an opening through the anterior abdominal wall by which food may be introduced directly into the stomach. It is performed in cases of œsophageal obstruction, both simple and malignant, where the patient is suffering from inanition, the result of his inability to pass sufficient food into the stomach through the œsophagus. In aged people, carcinoma; in young people, simple stricture,

the result of swallowing irritants, are the usual causes of œsophageal obstruction.

Instruments.—Scalpels, scissors, artery and dissecting forceps, retractors, a piece of rubber tubing a foot in length (a number twelve rubber catheter is very suitable), intestinal needles, ordinary needles, ligature and suture material.

Position.—The patient lies in the dorsal position. The surgeon usually stands on the right side of the patient (in performing Frank's operation he may prefer to stand on the left side). The assistant stands on the opposite side of the patient.

(*a*) Witzel's Operation

An incision is made three inches long in the upper part of the left linea semilunaris, passing through the skin and fasciæ

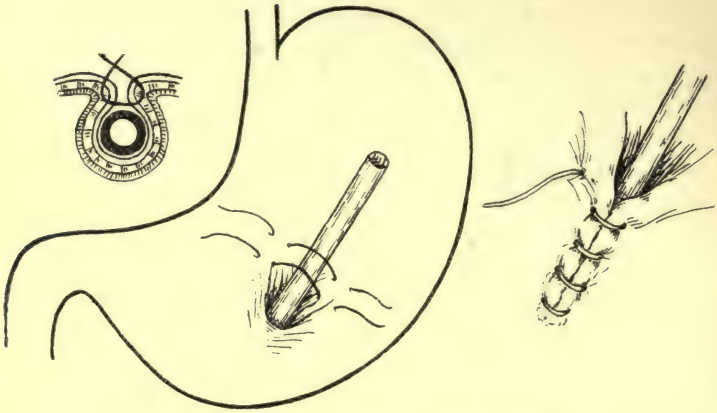


FIG. 117.—WITZEL'S GASTROSTOMY.

and exposing the aponeurosis of the external oblique. The linea semilunaris is divided vertically and the sub-peritoneal tissue exposed. In these cases there is as a rule very little fat in the sub-peritoneal tissue, and the peritoneum comes at once into view, and is opened in the usual way. Two fingers now search for the stomach and make out the condition of affairs. The stomach is found empty and collapsed under cover of the liver. After ascertaining that the condition of the pylorus is healthy, a portion of the greater curvature and anterior surface of the stomach is drawn into the wound. A point is now selected, about the middle of the anterior surface nearer the greater than the lesser curvature, for the introduction of the tube. The

stomach is well packed round with gauze, and the catheter is laid on the anterior surface of the stomach. A small hole is now made through all the coats of the stomach, this should be made parallel to the direction of the blood vessels and should be so small as to grip the end of the tube, which is introduced about an inch into the stomach. A suture should be inserted to fix it in place. The tube is now buried in the anterior wall of the stomach for the distance of one and a half to two inches by means of Lembert sutures, which draw up the stomach walls so as to form a canal in which the tube is lodged. The prominent margins of this tunnel are now carefully sutured to the parietal peritoneum so as to shut off the abdominal cavity and secure the stomach to the anterior abdominal wall, the sutures passing through the serous and muscular coats of the stomach. The muscular layer of the abdominal wall is brought together and the skin incision closed. A stitch fixes the tube to the skin wound. The wound is now dressed and the tube, which is proved to be patent by feeding the patient with a little milk as he lies on the table, is covered by the binder. This is especially necessary in those patients who have been operated on under a general anæsthetic, for if the tube is left exposed the patient may pull it out while still in a semi-conscious condition.

Comment.—Kocher advises that the rubber tube should be first buried in the stomach wall, and then a small opening having been made in the stomach the end should be introduced. The site of the opening is buried with Lembert sutures.

(*b*) Kader's Operation

Operation.—An incision is made about three inches long in a vertical direction, starting one inch below the costal margin, and about two inches to the left of the middle line. This incision divides the superficial structures and the anterior layer of the sheath of the rectus, exposing the left rectus abdominis muscle. This muscle is now split in the direction of its fibres and the two portions of the muscle retracted. The posterior layer of the sheath of the rectus is next divided and the peritoneal cavity opened as before. The fingers are introduced and the stomach sought for and pulled into the wound, a suture of thick silk is passed through the apex of the cone traversing the serous and muscular coats only, this serves to fix and steady the organ while the base of the cone is being sutured. The base of the stomach cone is then carefully sutured to the edges of the parietal

peritoneum, as in the last operation, with sutures which only traverse the serous and muscular coats of the stomach. Three purse-string sutures are passed in concentric circles round the stomach cone. A small aperture is made with a narrow-bladed knife in the stomach wall at the apex of the cone, care being taken to divide all the layers of the stomach wall, as the mucous membrane, which is only loosely attached by the sub-mucous coat, is apt to be invaginated. A small rubber tube is pushed about an inch into the interior of the stomach and the nearest purse-string suture is tightened up and tied. The tube, which

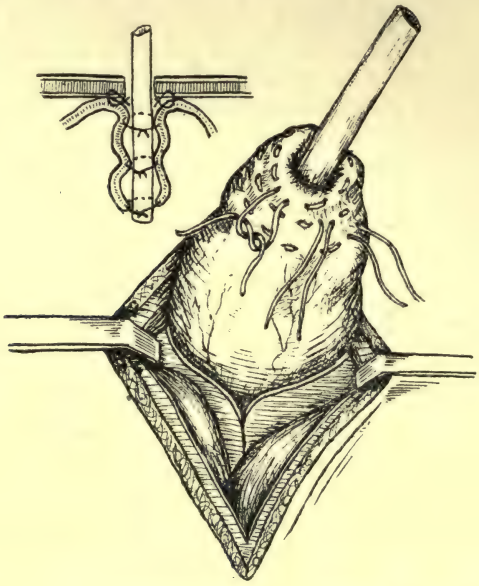


FIG. 118.—GASTROSTOMY BY KADER'S METHOD.

is fixed by the suture, is now pushed inwards, invaginating the wall of the cone until the second purse-string suture comes in contact with the tube. This suture is then tightened up and tied, and the same proceeding repeated with the third suture. In this way the cone is invaginated and the tube opens into the stomach at its apex, all leakage along the sides of the tube being prevented by the three layers of sutures. The margins of the rectus muscle are now sutured in place round the tube and the skin incision closed, the tube being fixed to the skin with a suture. The patient is fed at once to make sure that the tube is patent, and has not been constricted too tightly by the sutures. After

about ten days the tube becomes loose, and need only be inserted at meal times ; but by this time the peritoneal cavity is securely shut off, and the margins of the inverted cone fall together and form a mechanical valve, effectually preventing any leakage. The margins of the rectus muscle help also to form a sphincter.

(*c*) Frank's Operation

Position and Instruments.—The same as in the previous operation, with the exception that no tubing is required.

Operation.—This may be divided into three stages : (1) The incision in the abdominal wall ; (2) the fixation of the stomach ; (3) the incision in the thoracic wall and opening of the stomach.

Stage 1. *Incision in the Abdominal Wall.*—An incision is made about three inches long one inch from, and parallel to, the upper part of the left costal margin. This incision exposes the left margin of the rectus, the linea semilunaris, and the upper part of the external oblique muscle. These structures are now divided and the peritoneum opened with the usual precautions. With two fingers search is made for the stomach on the under surface of the left lobe of the liver. When found, the viscus is pulled into the wound.

Stage 2. *Fixation of the Stomach.*—A suitable point is now chosen as near the cardiac end as possible, and midway between the two curvatures, and a stout silk ligature passed through the serous and muscular coats and used to pull out and steady the viscus. The base of the cone, which is formed by pulling on the thread, is now sutured firmly to the parietal peritoneum, the sutures only piercing the serous and muscular coats of the stomach. The ends of the wound in the peritoneum are closed. In this way the organ is fixed to the anterior abdominal wall, and the cavity of the peritoneum shut off. The cone of stomach wall, which is now fixed in position, should be about one and a half inches in length.

Stage 3. *Incision in the Thoracic Wall and Opening of the Stomach.*—A small skin incision about half an inch long is now made opposite the middle and about one and a half inches from the first incision, so as to lie about half an inch above the costal margin. The incision passes through the skin and fasciæ down to the muscle (external oblique). With a pair of dressing forceps the skin and subcutaneous tissue which separates the two wounds is lifted up, and the forceps grasps the silk suture at the apex of the stomach cone, which by this means is drawn up under the bridge of skin into the upper wound. The lower wound is now

closed, the edges of the muscles being carefully sutured round the protruding portion of the stomach. A small aperture is next made in the apex of the cone, the margins of which are sutured to the skin of the thoracic wound. The sutures are made to traverse the whole thickness of the wall of the stomach. The patient may be fed at once through a No. 12 catheter introduced into the gastric opening. This operation can be performed only when the stomach is of considerable size.

Comment.—Witzel's or some modification of Kader's method, are the two procedures most in vogue at the present time. Frank's operation (sometimes termed Albert-Frank) is inferior in every way, and has been superseded by the other two.

It is a matter of little importance whether the tube is worn in position or whether it is inserted for each meal and removed afterwards. It is less trouble to keep it in place fixed by a small metal plate, which can be tied round the body with tapes. The tube is kept clamped to prevent leakage.

2. Gastrotomy

Indications.—The operation of gastrotomy means the opening of the stomach to enable the surgeon to carry out some further proceeding, the opening being closed immediately afterwards. The operation is called for (1) in order that foreign bodies, such as tooth-plates, hair-balls, etc., may be removed; (2) for the removal of bodies lodged in the lower part of the œsophagus; (3) for the dilatation of strictures simple in nature at either orifice of the stomach; (4) to excise a gastric ulcer which is bleeding.

Operation.—The position of the incision will vary with the nature of the operation; if the pylorus is to be stretched the middle line will be chosen; if the cardiac extremity of the stomach is to be dealt with then the incision is best made nearer the left costal margin. The operation will be described as if for removal of a foreign body. The incision is made vertically about three inches in length, starting one inch below the costal margin and two inches to the left of the middle line. The anterior layer of the sheath of the rectus is divided and the muscle exposed. This is now split in the direction of its fibres and the posterior layer of the sheath divided. The peritoneum is then opened, the edges being secured with catch forceps. Two fingers are inserted into the abdominal cavity and the stomach sought for and the position of the foreign body ascertained. In feeling for

the foreign body through the walls of the viscus, care must be exercised not to cause perforation of the stomach by any sharp points that the foreign body may present. The stomach and, if possible, the foreign body are brought into the wound and the general peritoneal cavity packed off with gauze. An incision is made in the anterior wall of the stomach of such a length as to allow of the extraction of the foreign body without unduly bruising the edges of the wound. This incision should be made parallel to the line of the vessels in the stomach wall, *i.e.* at right angles to the long axis of the stomach. With a long pair of dressing forceps or the finger the foreign body is next manipulated into the most suitable position for removal; it is then grasped and removed. The anterior surface of the stomach is carefully cleansed with swabs and the margins of the stomach wound united with sutures, the suture line being inverted with Lembert sutures, and the wound in the abdominal wall closed layer by layer.

3. Operations for Simple Stricture of the Pylorus

Different operations may be performed for the relief of simple strictures of the pylorus—

(*a*) Pyloroplasty.
(*b*) Gastro-enterostomy.

(*a*) **Pyloroplasty** (*Heineke and Mickulicz*)

This is a true plastic operation, with which is combined the division of the stricture.

Operation.—An incision is made in the linea alba or close to its left side, and the abdominal cavity opened with the usual precautions already described. Two fingers are introduced, and the pylorus is brought up into the wound. If necessary, adhesions are cleared to enable this to be done. The general peritoneal cavity is then packed off. A small incision is now made in the anterior wall of the stomach immediately to the right of the stricture. The margins of this wound, which is made in the long axis of the stomach, are separated and the stricture inspected through the opening. The incision is carried along the pylorus so as to divide the stricture. Free bleeding will occur now, as the incision cuts across the line of the vessels, which will need securing with forceps. Two small hooks are introduced, and the margins of the pyloric incision widely separated, as in Fig. 119, so as to convert the longitudinal incision into a lozenge-shaped one. When the sutures are in place the incision becomes transverse.

The margins are now sutured, as in Fig. 119, a continuous layer of sutures being passed through all the coats of the viscus

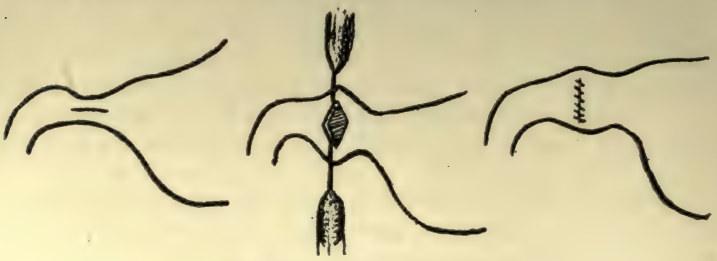


FIG. 119.—PYLOROPLASTY.

and the edges inverted with Lembert sutures passing through the serous and muscular coats. Or the mucous membrane may be first united and then the edges of the wound inverted with Lembert sutures. The packing is removed and the abdominal wound closed in the usual way.

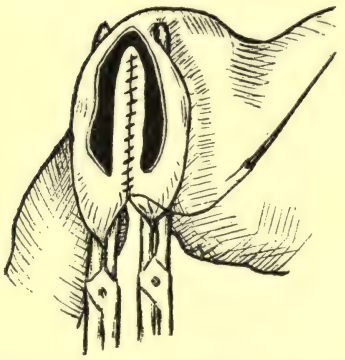


FIG. 120.—MICKULICZ'S PYLOROPLASTY AS CARRIED OUT BY FINNEY.

The above is the method described and depicted in most text-books, and is certainly one way of performing it. But Mickulicz remarks, "that is not the way we do it." He makes the longitudinal incision on the under surface of the constriction, a horseshoe-shaped opening into the stomach being the result. The two posterior walls are then united with Lembert sutures, and next with sutures through their whole thickness, the latter stitch being afterwards used to join the whole thickness of the two anterior walls, the margins of which are then invaginated with Lembert sutures.

A modification of this is often termed Finney's operation. Finney united with Lembert sutures the two posterior walls, *i.e.* the adjacent walls of the duodenum and stomach, before making the incision through the stricture. The rest of the operation is performed as before. The effect of incision on the underside of the stricture is not only to enlarge the opening, but also to lower the outflow from the dilated stomach.

(*b*) Gastro-Enterostomy

May be performed for the relief of simple as well as malignant tumours of the pylorus; it is described later.

Comment.—Pyloroplasty is not suited to all forms of even simple stricture at the pylorus. In cases of great thickening and hypertrophy, active ulceration, or dense adhesions, pylorectomy or gastro-enterostomy should be resorted to.

4. Operations for Hour-glass Contraction of the Stomach.

The operations for the relief of this condition need only be enumerated, as they are merely the application to this condition

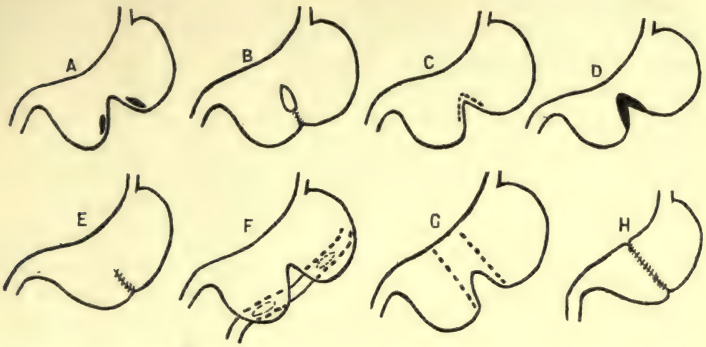


FIG. 121.—METHODS OF DEALING WITH HOUR-GLASS STOMACH.

A and B, Gastro-gastrostomy. C, D, E, Gastro-plasty. F, Gastro-jejeunostomy, both sacs. G, H, Excision of stricture and end-to-end anastomosis.

of operations which are described elsewhere. The first point of importance is to make out the condition of the parts, such as the relative size of the two sacs, condition of the intermediate stricture, and state of the pylorus, whether patent or constricted. The surgeon is apt to mistake one of the sacs for the whole organ, and the intermediate stricture for the pylorus.

The operation, to do good, must so arrange that the two sacs are emptied completely of their contents, which by the irritation of their decomposition tend reflexly to keep up the contraction of the constricted portions.

The following methods may be adopted:—

1. Digital dilatation poor and ineffective.

2. A gastroplasty, performed in the same way as in pyloroplasty, the intervening stricture being thus got rid of. This, however, may be inefficient, and the stricture return owing to ulceration being still active.

3. Anastomosis of the adjacent lower portions of the two sacs. This is useful where the pylorus is unaffected.

4. Gastro-enterostomy. This may be performed by anastomosing the larger sac to the small intestine or by anastomosing both sacs to the small intestine, and in thus draining both.

5. Excision of the constriction, as in pylorectomy. This is needlessly severe, and only applicable when the pylorus is normal.

5. Pylorectomy

Indications.—The operation of resection of the pylorus is undertaken chiefly for the removal of carcinoma of the pyloric wall causing stricture and obstruction to the outflow of the gastric contents. It is a severe operation, and only to be attempted in favourable cases, when there are no secondary growths, when the glands in the region are not extensively affected, and when adhesions are not too numerous. The general health of the patient is a most important consideration. The operation is not performed for simple stricture, as the same result can be brought about by performing the much less serious operation of gastro-enterostomy. The surgeon contents himself with performing gastro-enterostomy if any of the above contra-indications to pylorectomy are present.

Instruments.—In addition to the ordinary instruments for abdominal work a pair of gastric clamps should be provided. They are merely powerful intestinal clamps of sufficient length to grasp the whole width of the stomach. They may be either straight or curved.

Operation.—A mesial incision is made from the tip of the ensiform cartilage to the umbilicus, and the peritoneal cavity opened in the usual manner. The fingers are then inserted and the pyloric tumour sought for. The state of the surrounding parts is made out as regards adhesions to the neighbouring organs, condition of the glands, etc., any slight adhesions being separated with the fingers. The tumour is then drawn up into the wound. The small omentum above and the great omentum below the stomach are now perforated, and the two large gastric clamps are applied close together and well away from the tumour. The clamps should be applied rather obliquely, so as to remove

the greater part of the lesser curvature of the stomach. (See Fig. 122.)

The coronary artery is divided between double ligatures above the point where the stomach is to be cut through. The general peritoneal cavity is shut off by gauze placed round and behind the site of tumour. The stomach is then cut through with the knife between the two large clamps The lesser omentum and its contained glands are separated as far to the right as origin of the gastro-duodenal and pyloric branches of the hepatic artery, the two first being ligated while the last is left

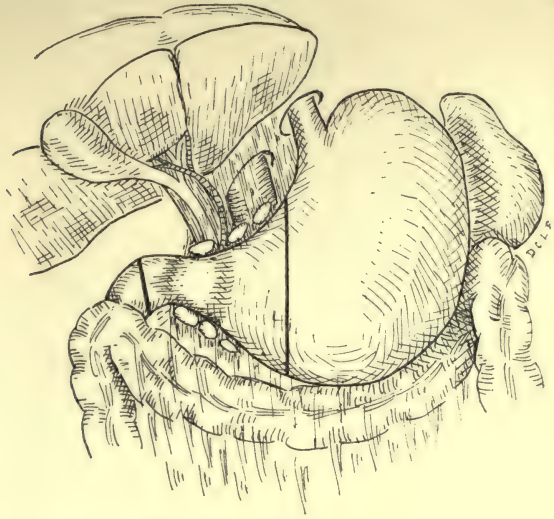


FIG. 122.—PYLORECTOMY.

Lines of division of stomach and duodenum; almost all the lesser curvature is removed.

untouched. The cut edges of the stomach with the clamps are wrapped in sterile gauze.

The other pair of clamps, together with the pylorus, are then turned over to the right side, exposing the head of the pancreas and the first and second parts of the duodenum. In the groove between these two structures runs the gastro-duodenal artery; the glands which accompany this vessel can now be removed without fear of hæmorrhage, as the vessel has already been tied. In turning the pylorus over to the right, the posterior aspect of the growth is brought into view and its limits and adhesions made out, and the possibility of performing the subsequent gastro-duodenostomy decided on. When this is to be done, two small

clamp-forceps are placed on the duodenum, side by side, wide of the growth, gauze is carefully packed round, and the duodenum cut across between the two forceps. The tumour is then removed. The cut edges of the duodenum, still clamped with the forceps, are wrapped in a swab till needed.

The wound in the stomach is then closed in the following manner. Immediately posterior to the clamp forceps a continuous suture is run from end to end of the section, transfixing both walls of the stomach, the ends are left long, and traction made on them as the clamp is removed. The traction serves to

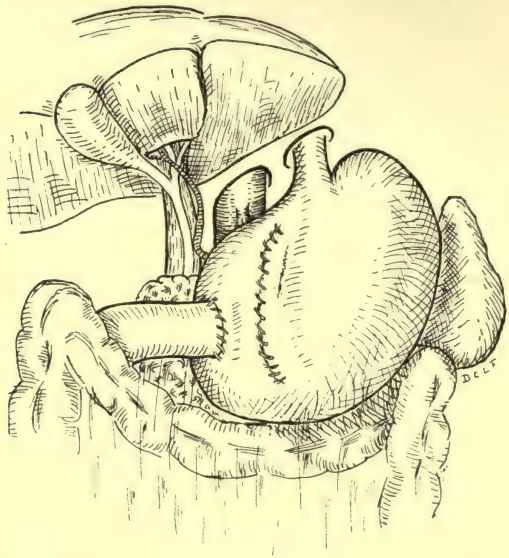


FIG. 123.—PYLORECTOMY—GASTRO-DUODENOSTOMY.

End of the stomach closed.

prevent any escape of the stomach contents, and steadies the organ for the next row of sutures. Any mucous membrane which protrudes unduly is now clipped off. The whole length of the section is now rapidly closed with a continuous suture passing through all the coats of the two walls of the stomach ; the ends may be knotted to the ends of the preceding suture. The whole line of suturing is now buried by inverting the line of section with a continuous Lembert suture.

The closed end of the stomach is now pulled over to the left so as to expose the posterior surface of the organ. The duodenum (still clamped) is brought up in contact with this surface at a

point which is nearer the greater than the lesser curvature of the organ. The two are now united together after the manner described under lateral implantation. A continuous suture passing through the serous and muscular coats of both unites the whole transverse diameter of the duodenum to the point selected on the posterior wall of the stomach. The parts having been carefully packed off, the clamp is removed from the duodenum, or may be shifted further along the gut. An opening is made in the posterior wall of the stomach of the same length as the cross diameter of the duodenum. Care is taken by the

FIG. 124.—PYLORECTOMY.

Posterior gastro-jejunostomy.

assistant to prevent escape of the stomach contents by clamping or grasping the organ on the proximal side of the opening. The two cut margins are united to each other by sutures which pass through the whole thickness of the walls of the stomach and duodenum. In this way the posterior walls are united together. The same thread may now be carried as a continuous suture through all the thickness of the anterior wall of the duodenum and the remaining cut edge of the stomach. The line of the last suture is then buried by a continuous Lembert suture, and the anastomosis is complete. After the line of suture has been cleansed, the surrounding gauze is all removed and the abdominal wound closed.

Pylorectomy with Gastro-jejunostomy

Operation.—The preliminary steps of the operation are the same as just described above, the necessity for some different method of procedure only appears when the tumour has been removed and it is then found that the end of the duodenum cannot be brought comfortably into contact with the posterior wall of the stomach. The cut ends of the stomach and duodenum are therefore completely closed. The method of doing this in the case of the stomach has already been detailed in the preceding operation. The closure of the duodenum can be safely and rapidly effected by crushing the cut end in powerful clamps till the tissues are greatly reduced in bulk (Fig. 109). A ligature is tied round this crushed stump, the thread being left long so as to steady the gut while a purse-string suture is inserted round the duodenum about a quarter to half an inch lower down, this purse-string suture not going deeper than the muscular coat. On tightening up this purse-string and inverting the ligature end of the duodenum the tube becomes completely and safely closed. A gastro-enterostomy may now be performed according to one of the methods to be presently described.

Pylorectomy with End-to-end Anastomosis

This was the original method of dealing with the divided ends of the stomach and duodenum, but is seldom pursued now, on

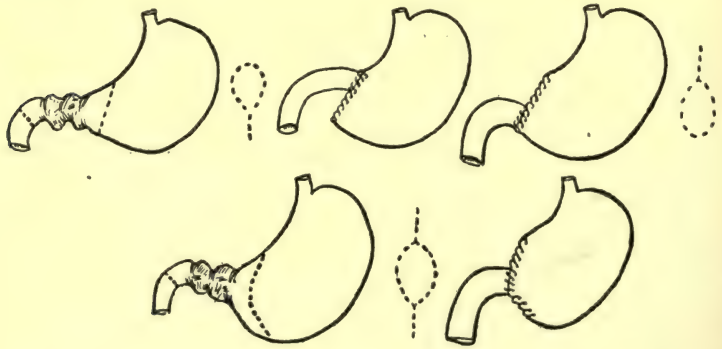


FIG. 125.—ORIGINAL METHODS OF PYLORECTOMY—NO LONGER USED.

account of the time taken and the dangers of the operation. Owing to the disparity in size between the duodenum and the

cut end of the stomach, a large portion of the latter has to be closed and only a small area, corresponding in size to the cross-section of the duodenum, left to be joined to the duodenum. This entails having a triradiate line of suturing at one point. In skin incisions a triradiate line of suturing is very difficult to approximate accurately; in the intestine it is almost impossible to invert the edges with any certainty, and this triradiate point of danger is a place where leakage is always apt to occur. As a rule the upper portion of the wound in the stomach was closed as already described, and the lower portion anastomosed with the duodenum. This was a better method than closing the lower part of the wound and leaving the upper part open for anastomosis, as in the latter case the lower part of the stomach was not allowed to empty completely. The closing of the upper and lower portions, leaving the middle part of the section for anastomosis, entailed the leaving of two triradiate points of danger from which leakage might take place. The accompanying Fig. 125 will explain the different methods. These methods are mentioned rather as a warning to the student against attempting such operations, some form of gastro-enterostomy being preferable in every case.

6. Gastro-enterostomy

This is the anastomosis of the stomach with any portion of the alimentary tract lower down. Different names are applied to special operations, according to the exact portion of the gut anastomosed to the stomach and to the way in which this anastomosis is carried out. Gastro-jejunostomy and gastro-duodenostomy are the terms applied when the jujenum or the duodenum respectively is joined to the stomach. The anastomosis usually joins the stomach to the upper part of the small intestine in order to lessen the loss of the secreting and absorbing surface of the intestinal tract.

Anatomy.—The first portion to which the stomach can be anastomosed is the second part of the duodenum. This portion of the duodenum lies to the right side of the third lumbar vertebræ. In front it is covered by peritoneum, and is crossed by the commencement of the transverse mesocolon. Behind it is connected by areolar tissue to the inner part of the right kidney and renal vessels. On its inner or left side lie the head of the pancreas and inferior vena cava. The common bile duct runs down in the groove between the head of the pancreas and this part of the duodenum posteriorly till it meets and joins the pancreatic duct (Duct of Wirsung). These two ducts then open by a common

orifice in the left half of the posterior wall of the second part of the duodenum. It will therefore be at once understood how easy it is after dividing vertically the peritoneum to the right of this part of the duodenum, separating the connective tissue posteriorly and dividing the right portion of the transverse mesocolon, to turn the duodenum forwards and to the left from off the right kidney. By so doing it can be placed in apposition with the anterior surface of the stomach near the lower margin of the pylorus and an anastomosis established. This is the operation of Gastro-duodenostomy. Gastro-jejunostomy may be performed in many ways. It will be remembered that from the lower margin of the stomach the gastro-colic omentum hangs down, and after looping up posteriorily, encloses the transverse colon. The transverse colon is attached by the transverse mesocolon to the posterior abdominal wall at the lower border of the pancreas and in front

FIG. 126. — ANTERIOR GASTRO-JEJUNOSTOMY.

FIG. 127.—POSTERIOR GASTRO-JEJUNOSTOMY — WITH NO LOOP.

FIG. 128.—GASTRO-JEJUNOSTOMY "EN Y."

of the second part of the duodenum. It will be seen that there are three ways of bringing the intestine into relation with the stomach. The first, Fig. 126, by carrying a coil of small intestine round the lower margin of the great omentum and fixing it to the anterior stomach wall; this is termed gastro-jejunostomy ante colica. The second, Fig. 127, by perforating the transverse meso-colon and fixing the loop of small intestine to the posterior wall of the stomach—this is termed gastro-jejunostomy retro colica posterior. The third way is to pierce the transverse meso colon and the anterior layers of the great omentum and fix the loop to the anterior wall of the stomach, this being called gastro-jejunostomy retro colica anterior. The first two of these methods are the common ones, and are usually known as anterior and posterior gastro-jejunostomy respectively. The second method is more frequently performed than the first, the third is now seldom or never performed. There is yet another way (Fig. 128), which differs

from the preceding methods in that the jejunum is cut across and the distal end anastomosed through a hole in the transverse mesocolon to the posterior wall of the stomach, while the proximal end is anastomosed to the distal portion of the intestine lower down, this being termed gastro-jejunostomy "en Y." The anastomosis in the last case may be performed to the back of the stomach as here stated, or to the anterior surface of the stomach.

Indications.—The operation of gastro-enterostomy is performed for—

1. Simple stricture of the pylorus which is not suitable for digital dilation or pyloroplasty.
2. Malignant stricture which is unsuited for pylorectomy.
3. Chronic dilation of the stomach which has resisted medical treatment.
4. Chronic gastric ulcer which has not reacted to medical treatment.

Gastro-duodenostomy

Instruments.—The same as in pylorectomy, for it is only when the abdomen is opened and the condition of the parts ascertained definitely that one can tell exactly what is needed.

Operation.—A vertical incision is made in the middle line from near the tip of the ensiform cartilage to the umbilicus, and the abdomen opened in the usual manner. The fingers are now inserted into the peritoneal cavity and the condition of the pylorus and surrounding parts made out. If adhesions do not bind the pylorus to the liver or pancreas too firmly, the operation can be carried out.

The stomach is drawn out of the wound and the finger passed above the first part of the duodenum into the foramen of Winslow. The peritoneum is now divided on the front of the right kidney about one to one and a half inches to the right of the second part of the duodenum. To do this the hepatic flexure of the colon must be depressed and pulled to the left, and, if necessary, the peritoneum to the outer side of the colon as it crosses the kidney divided so as to allow the duodenum to be freed from the kidney. In this way the colon can be displaced if necessary to the left without interfering with the vessels which pass to it across the second part of the duodenum The finger can then be passed inwards underneath the second part of the duodenum and the cellular tissue opened up between that structure and the kidney and renal vessels, and inferior vena cava. The duodenum can now be lifted up and folded over to the left, the hinge on which it folds being the transverse or third portion where it is

crossed by the superior mesenteric vessels. In this way the duodenum can be approximated to the anterior wall of the stomach at the pyloric extremity of the greater curvature. The general peritoneal cavity is packed off with gauze and the duodenum anastomosed to the stomach according to the method of lateral anastomosis. If it is wished to perform the anastomosis on the posterior surface of the stomach then the right portion of the transverse meso-colon must be divided. This is not so simple as forming the junction on the anterior wall of the stomach. The only portion of the peritoneum divided is on the anterior surface of the kidney and to the upper and outer side of the hepatic flexure. The portion of peritoneum, one to one and a half inches in extent, which is attached to the duodenum is now folded round on to the posterior raw aspect of the duodenum, and can be stitched to this surface. The gauze used to shut off the general peritoneal cavity, while the anastomosis was being performed, is now removed, and the parts returned to the abdomen. The external wound is then closed in layers.

Posterior Gastro-jejunostomy (retro colica posterior)

Operation.—An incision is made in the middle line from near the tip of the ensiform cartilage to the umbilicus, and the peritoneum opened. The fingers are introduced and the condition of the parts made out. The stomach is drawn into the wound and the coil of jejunum selected in the following manner. The stomach and omentum being lifted up, the right hand is passed behind the great omentum and transverse meso-colon, until it reaches the posterior abdominal wall up which the finger is passed until it comes in contact with the inferior layer of the transverse meso-colon and the third and fourth parts of the duodenum. The forefinger is now hooked to the patient's left, and the first coil it comes in contact with is brought to the surface. This is the first part of the jejunum, as the finger must have passed into the duodeno-jejunal flexure. The coil should be proved by following it up to its duodenal attachment. The stomach, which has been drawn up to the wound together with the great omentum and the transverse colon, is now drawn further out and held in the required position by the assistant. To do this properly the assistant lays his right hand palm uppermost on the anterior abdominal wall of the patient immediately above the wound, the stomach, omentum, and colon are placed on the palm and fingers of this hand and maintained in this position by placing the thumb

on top of them (see Fig. 129). A hole is now torn through the transverse meso-colon, the large vessels being avoided. Through the hole thus made the posterior wall of the stomach is made to protrude, being pushed forwards by the fingers of the assistant. The coil of jejunum already selected is brought up and laid alongside the posterior wall of the stomach. An ordinary lateral anastomosis is now performed between the posterior wall of the stomach and the highest part of the jejunum. Clamps are often applied before the suturing is commenced so as to prevent any escape taking place either from the stomach or the

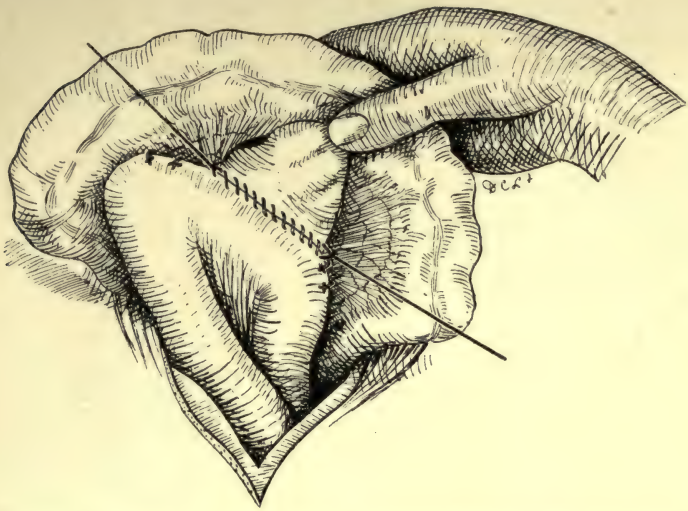


FIG. 129.—METHOD OF PERFORMING POSTERIOR GASTRO-JEJUNOSTOMY.

The hand of the assistant supporting the transverse colon, and pushing the stomach through the hole in the transverse meso-colon. The guide sutures point to the patient's right shoulder.

gut. If clamps are used they should be applied obliquely, so that their handles point to the patient's right shoulder. Whether clamps are used or not, the suture line should run in this direction, so that when the stomach is replaced in the abdominal cavity the long axis of the junction should run obliquely downwards and to the right in the natural direction of the upper part of the jejunum, so as to do away with the possibility of kinking of this part of the gut (see Fig. 127). The extent of the lateral anastomosis should be from two and a half to three inches, to allow for the subsequent shrinkage of the aperture. When the anastomosis is complete, the gut, together with the torn meso-colon, is attached to the posterior

wall of the stomach by one or two sutures placed beyond the ends of the anastomosis. The torn edge of the meso-colon round about should be similarly attached to the stomach. The gauze is then removed, the stomach replaced in the abdominal cavity, and the wound closed.

Anterior Gastro-jejunostomy (ante colica) (Fig. 126)

Operation.—The steps of the operation are the same as in the preceding method until the coil of jejunum has been isolated and a point selected about sixteen inches from the duodeno-jejunal flexure. This point is now laid in an iso-peristaltic manner, that is, from left to right over the front of the stomach, so that the peristaltic waves in the stomach and in the intestine are in the same direction. A lateral anastomosis is now performed between this portion of the jejunum and the anterior wall of the stomach, the junction being made near the greater curvature of the stomach and rather towards the pyloric end. The lateral anastomosis is performed in exactly the same way as has already been described. Clamps may be used to hold the two sides together and to prevent leakage. They can be removed after the third row of sutures has been inserted.

Gastro-jejunostomy "en Y" (*Roux's Operation*) (Fig. 128)

Operation.—The preliminary steps are the same as in the two preceding operations, the former of which it more closely resembles, inasmuch as the stomach, omentum, and colon are drawn out, turned upwards, and the transverse meso-colon perforated. A point is selected on the jejunum, about six inches from its commencement. The gut is clamped and divided completely at this point. The cut surface of the proximal portion is wrapped in gauze and laid aside, still grasped in the clamp. The distal end is now implanted into the exposed posterior wall of the stomach, rather nearer the greater than the lesser curvature. The union is made exactly in the manner already described under lateral implantation. The edges of the torn meso-colon are fixed to the posterior wall of the stomach. The proximal end of the gut, which was laid aside wrapped in gauze, is now implanted into the side of the distal portion of gut about four or five inches below the gastro-jejunal junction. This second anastomosis is also a lateral implantation. The organs are returned to the abdominal cavity and the wound closed. If preferred, the distal portion of the jejunum may be

anastomosed to the anterior instead of the posterior surface of the stomach.

Comment.—Of all the methods adopted for joining the stomach to a portion of the intestinal tract lower down, the operation of posterior gastro-jejunostomy is by far the most satisfactory. An ample opening can be made between the stomach and the portion of gut which lies normally just behind it ; there is no loop between the duodeno-jejunal flexure and the anastomosis in which fluids can collect ; the opening is situated in the best position for draining the stomach as the patient lies on the back, and the state of the colon does not affect the opening.

Gastro-duodenostomy has no advantage over posterior gastro-jejunostomy ; it is a little more difficult to bring the suture line to the surface, and in many cases where the pylorus is involved adhesions are present or growth has extended too far to enable the operation to be performed. Anterior gastro-jejunostomy is easily performed, but the long loop of bowel which has to be left between the junction and the duodeno-jejunal flexure is a grave disadvantage. A loaded transverse colon may drag severely on the suture line.

The " en Y " operation is more complicated, a double anastomosis having to be carried out. Its advantage is that a vicious circle cannot form.

Vicious Circle.—Apart from the ordinary dangers which accompany operations on the stomach and intestines generally there is one which is peculiar to gastro-enterostomy operations. This is the persistent vomiting which may be set up owing to the bile and pancreatic juices being unable to get past the anastomosis into the distal portion of the gut and passing into the interior of the stomach instead. This may be due to kinking at the anastomosis, for if there is a loop of bowel on the proximal side of the anastomosis, when this fills with secretion, it will sag, and by its size press on and occlude the distal portion of the gut. Several remedies for this have been devised—lateral anastomosis between the distal and the proximal portions of the gut ; the operation " en Y " ; the formation of pleats and spurs as suggested by Kocher ; but undoubtedly the best way of dealing with this risk is to prevent the possibility of any loop forming by placing the anastomosis as near the duodeno-jejunal flexure as possible.

Another cause of vicious circle is the twisting of the gut in such a way as to form an artificial volvulus. This may take place in an attempt to transform an anti-peristaltic position into an iso-peristaltic one. If the twist is made in the wrong direction a volvulus is formed, and the anastomosis fixes it in position.

7. Operation for Perforated Gastric Ulcer

Preliminaries.—When a patient has to be operated on for a perforated gastric ulcer, a variable time will have elapsed between the time of perforation and the necessary operation, and, as a rule, the signs of sudden acute general peritonitis are well marked. The patient is often collapsed and suffering from severe shock. In such cases it is as well to give an injection of morphia while the preparations are being carried out. On no account should the stomach be washed out.

Operation.—When the patient is under the influence of the anæsthetic a more careful examination may be made. Fluid will probably be made out and the absence of the liver dulness may or may not be ascertained. An incision three inches long is made in the middle line above the umbilicus, and the peritoneal cavity opened. Fluid will probably escape, together with portions of food which have made their way through the aperture in the stomach wall. The finger is at once passed up under the liver, and the stomach sought and pulled gently into view. Adhesions may or may not be found between the stomach and the under surface of the liver, according to the time which has elapsed since the perforation. The finger now rapidly passes over the anterior surface of the organ, seeking an indurated area with a small umbilication in the centre, which often gives to the finger the same sensation as the os uteri of a multipara. Luckily, in about seventy per cent. of cases the rupture is situated on the anterior wall of the stomach, and usually near the lesser curvature at the pyloric extremity. Should the rupture not be found on the anterior surface, a hole should be made in the great omentum, just below the greater curvature, and the finger introduced into the lesser peritoneal sac to explore the posterior wall of the stomach. If the rupture is on the posterior wall there will be greater evidence of mischief when the lesser peritoneal sac is opened. As a rule, ulcers on the posterior wall of the stomach contract firm adhesions to the pancreas, and therefore do not infect the peritoneal cavity. As soon as the rupture is found it is at once plugged with the finger till gauze is inserted to prevent further escape. The attention is now turned to the general peritoneal cavity, which is flushed out with warm normal saline solution so as to get rid of the major part of the irritating fluid. This, as a rule, improves the general state of the patient.

(If litmus is applied to the fluid issuing from the hole in the wall of the stomach it will be found to have a strongly acid reaction.

Many patients with gastric ulcer have hyper acidity of the gastric juice. If litmus be applied to the fluid in the general peritoneal cavity it will be found to have an alkaline reaction, showing that the peritoneum is doing its best to neutralize the irritating action of the escaping fluid.)

Very little time should be spent in flushing out the abdominal cavity at this stage, the end of the tube being left in with an assistant attending to the flushing apparatus to see that a constant stream is allowed to run while the surgeon turns his attention to the rupture. The rupture is now closed with one or two sutures through the whole thickness of the stomach wall and the edges inverted with Lembert sutures. This is no easy matter, as the walls are indurated and the stitches often cut out. A portion of the wall of the stomach may have to be removed in order to close the margins satisfactorily, or the omentum may be used to seal the suture line. On the posterior wall the suturing is more difficult still, the stomach having to be thrown upwards to allow access through the hole in the omentum. By the time the rupture is closed the general peritoneal cavity should be nearly clean. The surgeon now pays special attention to certain peritoneal recesses in which fluids are apt to collect and which otherwise escape thorough flushing out. These are—

1. The renal fossa on either side.

2. The diaphragmatic surface of the liver on either side of the falciform ligament.

3. The deep fossa lying between the under-surface of the right lobe of the liver and the front of the right kidney (Robson).

4. The basin of the pelvis. To irrigate this last the left hand is passed into the wound, a stab wound is made in the middle line, a short distance above the pubis, while the hand internally protects the intestines and bladder. A tube is now inserted into the bottom of the pelvic cavity, which is well flushed out.

When the abdomen is thought to be clear the upper part of the upper wound is closed, a tube being left in the lower part of the wound. The lower wound is left with the tube in the pelvis.

After-treatment.—The patient is propped up in a sitting position as soon as he has recovered sufficiently from the anæsthetic. Morphia may be given to allay the pain; strychnine may be given if the pulse is bad. Every four hours a thin tube may be inserted into the drainage tube and the pelvic cavity emptied by sucking up the fluid with a syringe. At the end of twenty-four to forty-eight hours the tube in the upper wound may be removed, that in the lower wound may be left a little longer, the time depending on the amount and nature of the

fluid. Saline per rectum should be given for the first three days, the patient may then begin to take fluids by the mouth.

OPERATIONS ON THE LARGE INTESTINE

Removal of the Vermiform Appendix

Anatomy.—On the surface the junction of the appendix to the cæcum is situated immediately below McBurney's point, which is found by bisecting the line drawn from the umbilicus to the anterior superior iliac spine on the right side; this point corresponds to the position of the ileo-cæcal valve. The appendix varies in length, but on an average measures about three and a

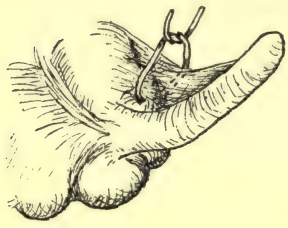


FIG. 130.—LIGATURE OF MESENTERY AND VESSELS.

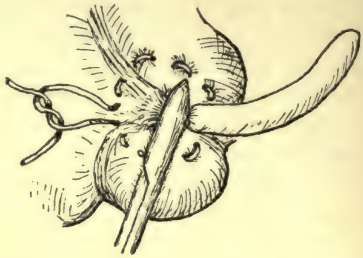


FIG. 131.—CRUSHING THE BASE OF THE APPENDIX AND INSERTING THE PURSE-STRING SUTURE.

half inches. The position in which it lies varies like that of all the viscera supplied with a mesentery; the three chief positions in which it is found are, in their order of frequency—(1) hanging over the edge of the pelvis in front of the iliac vessels; (2) pointing upwards and to the left towards the spleen, in the so-called north-east position; (3) passing straight upwards, lying behind the cæcum and ascending colon in one of the peritoneal fossæ, usually the retro-colic. The appendix is provided with a mesentery, the meso-appendix, which is attached to the lower or left layer of the lower part of the enteric mesentery.

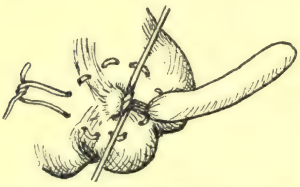


FIG. 132. — APPLYING THE LIGATURE TO THE CRUSHED PORTION BEFORE DIVIDING IT.

In this meso-appendix run the blood-vessels, the artery being one of the terminals of the ileo-colic artery, the vein a tributary

of the superior mesenteric vein. In the female there may be an anastomosis with the right ovarian vessels. It is important to remember the morphological relation borne by the appendix to the cæcum, as its position in the adult is the more readily understood. The appendix is the true apex of the cæcum, and from its base the three longitudinal muscular bands start. As development proceeds, the right side of the cæcum grows far more rapidly than the left, so that the free end of the cæcum in the adult is formed by what originally was its right side, the left side forms only that portion lying between the appendix and the ilio-cæcal valve. This inequality of growth causes the opening of the appendix to look to the right. It will be readily understood, therefore, why the longitudinal bands of the cæcum form such a sure guide to the position of the appendix. After one or more attacks of appendicitis, the appendix is usually fixed in position by adhesions. It is the separation of these adhesions which forms the chief difficulty in the operation for appendicectomy.

The operation for the removal of the appendix during the quiescent stage, or when no pus is present, will be first described; the treatment of an appendix abscess being dealt with later.

Operation.—The position of the incision is marked as follows. An imaginary line is drawn from the umbilicus to the anterior superior spine on the right side, this line is divided into thirds, the junction of the middle and outer thirds is made the centre of the incision. This should be about three inches in length and parallel to Poupart's ligament. If there have been recurrent attacks of appendicitis and adhesions are anticipated, it is better to make the centre of the incision at the mid point of the above line (McBurney's point). The incision passes down to the external oblique muscle, which is fleshy in the upper and tendinous in the lower part of the wound. The fibres of the muscle and aponeurosis are split in the direction in which they run. On retracting the edges of the external oblique muscle, the internal oblique is brought into view. This muscle is now split in the direction of its fibres and the transversalis muscle treated in the same way. At this level the direction of the fibres of the two last muscles is almost identical. The transversalis fascia and the peritoneum are cautiously divided in the usual way. The margins of the wound are now widely retracted and the finger introduced to search for the appendix. If no adhesions are present the cæcum is pushed over to the right and the appendix hooked up from its inner and posterior aspect.

If adhesions are present the omentum and loose coils are pushed over to the left and the peritoneal cavity protected by

gauze. The cæcum is identified by its size and the presence of the longitudinal muscular bands. On following one of these bands down the appendix will be found; or the ileo-cæcal junction may be sought and the appendix found a little below it. Any adhesions that are present must be dealt with. The appendix may be bound down in any position, and adherent to the ovary, bladder, rectum, small intestine, omentum, iliac vessels, posterior surface of the ascending colon, or even completely buried in the wall of the cæcum. Care and patience are necessary to clear it, as ulceration may have taken place through the wall of the appendix and the hole may only be closed by the adhesion. When the appendix is brought into the wound, the meso-appendix is clamped and ligatured. Forceps are applied to the base of the appendix, which is crushed firmly in their grip. These forceps are used to steady the cæcum while a purse-string suture is inserted round the base of the appendix about a quarter of an inch from its junction with the cæcum (Fig. 123). A ligature is next applied to the crushed portion of the appendix as the forceps are removed. The appendix is divided on the distal side of the ligature, the ends of which should be left long, and are held by the assistant. The purse-string suture is now tied while the assistant depresses the stump of the appendix into the cæcal wall, and cuts his ligature short. An extra stitch can be put in the wall of the cæcum, if required, to bury the stump still further. The parts are examined, dried, and the abdominal wall closed. The advantage of making a gridiron incision through the abdominal wall is now apparent, as the edges of the split muscles fall naturally together, and can be sutured without tension. No muscles have been divided, and the different directions in which they are split greatly diminishes the risk of a hernia.

Operation for an Appendix Abscess

If a tumour can be felt, an incision should be made over it or a little to its outer side to avoid opening into the general peritoneal cavity, if adhesions have already formed. If no tumour can be felt, an incision similar to that in the preceeding operation should be made. Great care must be taken in opening the peritoneum to avoid wounding a coil of adherent bowel. If the intestines are adherent to the anterior abdominal wall they should be interfered with as little as possible. The finger is bored down between the coils until the abscess is opened. If the matted parts are free from the anterior abdominal wall, the general peritoneal cavity should be protected by gauze before endeavouring

to reach the abscess by burrowing down on the outer side of the omentum and cæcum. The pus is allowed to escape and is swabbed out of the cavity. The appendix may be found loosely adherent to the abscess cavity, or may actually have sloughed off; it should be removed in all cases where it can easily be got at. Opinions differ as to whether it should be sought for and removed in all cases; but if there is much difficulty it seems much safer to drain the abscess and put off the removal of the appendix to a future date when a general peritonitis is not such a danger. After the appendix has been removed and the cavity dried out, a drain is inserted and the wound partially closed.

If a general peritonitis has been set up, it is a good plan to make a fresh opening in the middle line and place a drain down to the bottom of the pouch of Douglas.

If the appendix has been left and the abscess only drained, six weeks to two months should elapse before the operation for the removal of the appendix is undertaken. By this time a great many and perhaps all the adhesions will have disappeared. This is especially the case in young people and children.

Resection of Portions of the Large Intestine

Resection of portions of the large intestine, or, as it is termed, colectomy, is indicated for reasons similar to those enumerated for resections of portions of the small intestine. The technique of the operation is the same, but in the more fixed portions of the colon is rather more difficult on account of the absence or shortness of the mesentery. The formation of an artificial anus is more common in connection with this operation than in enterectomy. The use of a Murphy's button in dealing with the colon is accompanied by fewer risks than when used higher up the intestinal canal.

Elimination of the Intestine and Short-Circuiting

The elimination of bowel means so arranging the lumen of the intestine that the current of fæces no longer passes over a certain segment, or only does so in diminished amount, thereby giving a rest to that particular portion. The method by which this is brought about is termed short-circuiting, and consists in varying forms of anastomosis, with or without the formation of a fæcal fistula or an artificial anus.

Indications.—1. Simple stricture, in place of performing enterectomy.

2. Simple stricture with a large number of adhesions, the division of which would involve an extensive operation.

3. Chronic ulceration or other disease, such as fistula, where it is important to eliminate a portion of bowel.

4. Malignant stricture, where the state of the patient or the presence of secondary growths prohibits a radical operation.

Elimination of a portion of intestine may be partial or complete, and is carried out in the following ways :—

FIG. 133.—PARTIAL ELIMINATION OF GUT.

Partial Elimination.—1. Lateral anastomosis of the gut above to that below the stricture.

2. Division and closure of the gut above the stricture with lateral implantation or lateral anastomosis to the gut below.

3. Division and closure below the stricture, with lateral implantation or lateral anastomosis to the gut above.

4. Formation of a fæcal fistula.

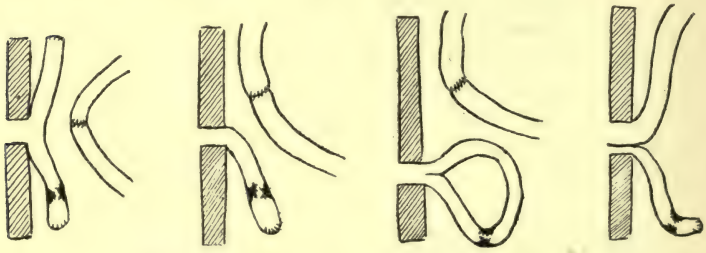


FIG. 134.—TOTAL ELIMINATION OF GUT.

In all these cases it will be noted that the portion of gut containing the obstruction is only partially thrown out of use, and that fæcal matter can still reach the stricture. In many cases the formation of a cul-de-sac is undesirable, as in it fæcal matter can collect and decompose, irritating the part one wishes to keep at rest.

Total Elimination.—1. Division above and below the growth, closure of both ends when a fæcal fistula already exists; restoration of the lumen of the main gut.

2. Division above and below the growth, closure of one end, the other forming a fistula; restoration of the lumen of the main gut by anastomosis.

3. Division above and below the growth, each end forming a fistula; restoration of the lumen of the main gut by anastomosis.

4. Formation of an artificial anus above the growth.

5. Division above and below the growth, the lumen of the main gut being restored by anastomosis, while the ends of the eliminated portion are closed. This method is highly undesirable, as in diseased and ulcerated intestine the secretion would probably exceed the absorption; the gut would become distended and the stitches give way.

COLOTOMY

The term "colotomy" signifies the opening of the large intestine and the formation of an artificial anus. It should, more correctly, be termed "colostomy."

Indications.—The operation is performed for the relief of obstruction in the colon, commonly for the relief of cancer of the rectum.

It is performed as a palliative measure in cases of cancer where no obstruction as yet exists, in recto-vesical and recto-vaginal fistulæ, and in long-standing cases of ulceration of the rectum with the formation of fistulæ, and, lastly, in infants who suffer from imperforate anus and in whom the operation in the perineum has failed to find the lower end of the gut.

Lumbar Colotomy is the older of the two operations, and was planned according to pre-Listerian methods, so as to avoid opening the general peritoneal cavity. The opening was made in the loin, most frequently the left one, above the crest of the ilium. The operation is now seldom performed, and in the dead body is extremely difficult and practically impossible when formalin has been used.

Inguinal Colotomy, which has largely supplanted lumbar colotomy, is a transperitoneal operation, in which the large intestine is opened above Poupart's ligament. The operation is usually carried out on the left side, and the pelvic colon is the portion of gut brought into the wound and opened. If performed on the right side the cæcum is the portion of the gut opened into.

Anatomy.—The descending colon, commencing above at the

splenic flexure, where it is attached to the diaphragm by the phrenico-colic ligament, descends along the outer margin of the left kidney, at the lower border of which it lies in front of the left quadratus lumborum. This part of the colon is covered in front and at the sides with peritoneum, being separated from the muscle posteriorly by cellular tissue. Though this is considered the normal arrangement of the peritoneum, a descending meso-colon is found in 36 per cent. of cases attached along the outer border of the kidney (Treves). The direction of this portion of gut is downwards and inwards, it ends at the iliac crest, where it becomes continuous with the iliac colon. The iliac colon passes downwards and then inwards, lying on the iliacus and psoas muscles to the inner border of the latter, where it becomes continuous with the pelvic colon. The iliac colon in length measures five or six inches, it has no mesentery, but is covered in front and at the sides by peritoneum, which binds it down to the muscles. The pelvic colon, if lifted out of the pelvis, is found to form an omega-shaped loop which possesses a mesentery, allowing considerable movement. The length of the pelvic colon is about seventeen inches. It usually lies coiled up in the cavity of the pelvis. The line of attachment of the mesentery of this part is V-shaped, one limb of the V passing up along the inner border of the psoas muscle as high as the bifurcation of the left common iliac vessels, the other limb, starting from here, passes to the middle of the third piece of the sacrum. In the acute angle thus formed is the intersigmoid fossa, in which a coil of intestine may become strangulated. In this mesentery run the sigmoid arteries from the inferior mesenteric.

Lumbar Colotomy

This, as already stated, is usually performed on the left side, and will be described in this situation.

Position.—The patient should lie rolled on to the right side, with a hard pillow or sandbag placed under the right loin so as to open up the interval between the iliac crest and the last rib, and put the structures on the left side of the body on the stretch. The surgeon stands behind the patient with an assistant facing him on the opposite side of the table. A good light is necessary.

Operation.—*Stage* 1. The course of the colon is marked out by drawing a line from the mid-point of the crest of the ilium vertically upwards to the twelfth rib, the mid-point of the iliac crest being measured between the anterior and posterior superior

spines. The twelfth rib is a structure of variable length, so that the line will meet it either at its tip or some point posterior to this. The incision may be oblique or transverse—the former is preferable—about three and a half inches in length, the mid-point being at the centre of the line already marked out. The incision should lay bare the latissimus dorsi and external oblique muscles, the fibres of both run vertically at this point. These are cut through, and the internal oblique and transversalis exposed in turn and divided, the muscular structures should be divided for the whole length of the original incision. Any bleeding points are now secured. If any lumbar nerves are seen they should be drawn aside rather than divided. If the bowel is distended it will now bulge up into the wound covered by the fascia transversalis, in which case the rest of the operation is easy. On the other hand, should the bowel be collapsed and the patient fat, considerable difficulty has yet to be met with. The fascia transversalis is cut across for the whole length of the original wound. The incision will now expose the outer border of the quadratus lumborum and the extra-peritoneal fatty tissue, broad retractors are inserted and the wound held widely open. The kidney will probably come into view, and needs pressing upwards.

Stage 2.—The finger is now pushed into the exposed fatty tissue, which must be opened up freely if a collapsed colon is to be felt and brought to the surface. The finger passes inwards in front of the quadratus lumborum towards the psoas, as it is the non-peritoneal surface of the colon, lying in the angle between these two muscles, which must be sought for. The chief guides to the recognition of the bowel are (1) the line already marked on the skin ; (2) the relation borne by the colon to the kidney, psoas, and quadratus lumborum ; (3) the sensation of thickness given to the fingers by the gut wall as compared with the thinness of the wall of the small intestine ; (4) the presence of scybala in the gut ; (5) seeing the posterior longitudinal muscular band. Access to the depths of the wound is difficult in fat people, in whom there is a considerable thickness of extra-peritoneal as well as sub-cutaneous fat. The bowel can be brought nearer the surface by the assistant pushing in the anterior abdominal wall with his clenched fist. This is easier than rolling the patient on the back, as some advise. The bowel having been recognized, it is brought to the surface with the fingers. Owing to the fixity of this portion of the intestine it cannot be drawn well out of the wound, and even in satisfactory cases can only be pulled to the surface. The ease with which this may be done

depends largely on the extent to which the sub-peritoneal fatty tissue has been opened up. If the bowel is found to possess a meso-colon, the peritoneal cavity must be opened into and the bowel pulled up as before. Forceps are attached to the posterior surface of the bowel, which is thus held in the wound while sutures are passed deeply through the abdominal walls at either end of the skin incision, two or more being needed at either extremity of the wound. When all are in place they are tightened so as to shorten the wound to the portion that is blocked by the colon. The posterior wall of the gut is now fastened with sutures to the margins of the incision so as to shut off the deeper parts of the wound and the peritoneal cavity, if that has been opened. If the condition of the patient warrants it, the opening of the bowel can be deferred till a later date, by which time adhesions will have formed.

Stage 3.—If the obstruction is acute, the whole operation must be performed at one sitting. A purse-string suture is passed so as to enclose a portion of the gut wall in the long axis of the wound. The gut is opened in the middle of this suture and a colotomy tube inserted, the suture being tightened to fix the tube in position. To the end of the tube is attached a short, wide rubber tube to carry the escaping bowel contents well away from the scene of operation. Dressings are applied, and the patient sent to bed to lie on the back, near the left side of the bed, over the edge of which the rubber tube is led to drain into a receptacle. The bowel can be gently washed out through the tube, should it become blocked with hardened fæces. Every attention should be paid to prevent the wound becoming infected till adhesions have had time to form. In two to four days the tube will become loose, and then the same remarks made in connection with inguinal colotomy will apply here. There is an obvious advantage in performing the operation in two stages, for not only is the peritoneal infection guarded against, but the deep planes of fatty tissue through which infection is liable to spread are shut off before the bowel is opened.

Inguinal Colotomy

Position.—The patient lies on the back, near the left side of the table. The surgeon stands on the left side, with the assistant opposite him.

Operation.—An incision similar to that made in appendicectomy, only on the left side, two to two and a half inches long, is made one and a half inches above and parallel to the outer part

of Poupart's ligament. Mr. Cripps, in order to lessen the tendency to subsequent prolapse of the bowel, makes the "incision nearly as high as the level of the umbilicus, so that the wall of the lower part of the abdomen, where the pressure is greatest, is left intact." The incision passes down through the layers of the abdominal wall, and the peritoneal cavity is opened in the usual way. In a case of acute obstruction the colon will bulge into the wound. In other cases it must be sought for. The finger is passed into the abdominal cavity, and search made for the colon as it passes over the iliacus and psoas. Should it not be found at once, the hand should explore towards the brim of the pelvis. The fingers should thoroughly explore the cause of the obstruction as regards its site, shape, adhesions, and secondary growths, so as to gain information if a subsequent operation for the removal of the obstruction is indicated.

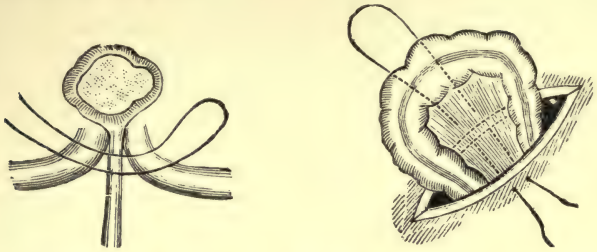


FIG. 135.—INGUINAL COLOTOMY, SHOWING FIXATION STITCH PASSING THROUGH MESENTERY AND ABDOMINAL PARIETES.

(*Rose and Carless.*)

The colon is recognized by its sacculations, appendices epiploicæ, longitudinal bands, and the thickness of its walls. A loop of the pelvic colon is drawn up into the wound, the upper and lower ends identified, and the gut pulled out from the upper end and passed in again at the lower end of the wound until no more can be drawn down. This prevents the subsequent prolapse of slack bowel through the artificial anus. When the highest portion of bowel available without tension has been brought into the wound, the surgeon has the choice of two methods of precedure, according to whether the condition is acute or chronic. If the operation is performed for the relief of chronic obstruction before acute symptoms have supervened, the opening of the bowel should be postponed till a later date.

If the condition is acute, the gut must be opened at once. The parietal peritoneum is sewn to the serous coat of the bowel all round the margin of the gut, the two extremities of the wound

are then closed. A purse-string suture is passed through all the coats of the bowel, and a small hole made, into which is inserted the end of a glass tube, which is fastened into position with the purse-string suture. The parts are well packed round, covered with protective and swabs, and the intestine cleared out through the tube before the patient leaves the table.

If the operation can be performed in two stages, the bowel may be simply fixed till adhesions have formed between it and the raw margins of the wound. These will be quite firm at the end of forty-eight to seventy-two hours. Many different methods of fixing the bowel are used. The simplest is just to transfix the mesentery with a pair of artery forceps, the ends of which are then protected with swabs, and the parts packed round. A good method is to pass a strong silkworm gut suture through the whole thickness of the abdominal wall on one side of the wound, through the mesentery, and then through the abdominal wall on the opposite side of the wound. The needle is then made to pierce the same structures again in the opposite direction, so as to end quite close to where it started. The two ends of the suture are tied and pull the margins of the wound and parietal peritoneum into apposition with the mesentery behind the gut. Additional sutures are put in the parietal peritoneum at each end of the wound and the skin incision sewn close round the protruding knuckle of bowel. Four or five days later the bowel can be cut away almost level with the skin. No anæsthetic is needed for this proceeding. The vessels in the bowel wall need securing, as they bleed freely.

After-treatment.—Large dressings must be applied and frequently changed, and the parts kept washed till the wound has firmly healed. The patient should then be fitted with a colotomy truss to prevent a continual discharge taking place. Great attention must be paid to the diet to prevent either constipation or diarrhœa.

Comment.—The advantages of inguinal over lumbar colotomy are—

1. The patient lies on the back, and is in a better position to take the anæsthetic—a very important consideration in those suffering from acute obstruction.

2. The wound, especially in a stout person, is not so deep, and the access to the required portion of gut easier.

3. There is less risk of failing to find the gut owing to abnormalities of the mesenteric attachment, although this may cause difficulty even in the anterior colotomy.

4. The cause of the obstruction can be readily explored with a view to its removal at a later date.

5. The intestine being more movable, it is easier to pull a knuckle into the wound so as to have an efficient spur, and so prevent the fæces passing on to where the growth is situated in the distal portion.

6. The artificial anus is more readily attended to by the patient when it is situated in front than when situated in the loin. This is an important consideration in the subsequent comfort of the patient.

The disadvantages are—

1. That great care must be taken to prevent soiling the peritoneal cavity in cases of acute obstruction, where the intestinal contents must be evacuated at once. This, however, is not a disadvantage which applies solely to the inguinal operation, for in lumbar colotomy, if the peritoneal cavity is opened, as in cases where a descending meso-colon is present, it is much more difficult to shut off the general peritoneal cavity than in the inguinal region.

2. Owing to the mobility of this portion of the colon, there is more likelihood of a prolapse occurring than from the more fixed descending colon. Directions for pulling down the gut so as to minimise this risk have been given.

THE LIVER

Anatomy.—The liver in the adult occupies the right lumbar, right hypochondriac, and the epigastric regions. In the infant, where it is relatively larger than in the adult, it occupies the left hypochondriac region as well. The upper border lies immediately under the diaphragm, and crosses the mid line at the level of the xiphisternal junction or the eighth dorsal spine. It reaches about three inches to the left of the mid-sternal line in the fifth interspace, where it cannot be differentiated by percussion from the heart dulness. To the right it ascends in full expiration to the lower border of the fourth rib. The lower border can be easily made out by percussion, or even palpation, as it crosses the costal angle ; it corresponds to a line drawn from the eighth left to the tenth right costal cartilage. The lower border, as it crosses the linea alba, corresponds almost exactly to the transpyloric plane. To the left the lower border rises from the eighth left costal cartilage to the fifth interspace, three inches from the mid-sternal line. To the right it passes downwards and outwards

about a quarter or half an inch below the costal margin. In the mid-axillary line it lies just below the most dependent part of the tenth rib. Posteriorly, the liver reaches as high as the inferior angle of the scapular or the eighth rib, and as low as the twelfth rib or the level of the second lumbar spine. Neither of these limitations can as a rule be made out posteriorly, as the upper border is covered by such a depth of lung, while the lower border merges into the kidney and muscular dulness of the loin.

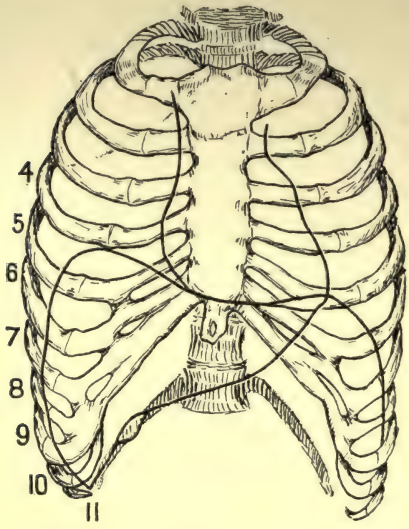


FIG. 136.—SURFACE MARKING OF THE LIVER, HEART AND DIAPHRAGM.

The relation of the right lung to the liver may be marked out by drawing a transverse line outwards from the level of the tenth dorsal spine to the mid axillary line where it crosses the eighth rib. From here the line slopes gently upwards and forwards to the sixth chondro-sternal junction. This line marks the lowest limit of the lung. The reflection of the right pleura is of great importance. Starting from the back of the xiphisternum, it passes down the back of the seventh costal cartilage to the eighth costo-chondral junction in the mammary line. From here it passes downwards and outwards across the ends of the ninth and tenth ribs, crossing the latter in the mid-axillary line, where it reaches its lowest level. From here the line of reflexion rises slightly as it passes inwards across the twelfth rib to the vertebral column at the level of the upper border of the twelfth dorsal spine.

The liver is completely invested by a peritoneal capsule, except that portion of the right lobe which is enclosed by the two layers of the coronary ligament. This portion, which is known as the bare area, is only separated from the lower surface of the diaphragm by a little loose cellular tissue.

Needless to say, the relations of the liver may be very materially altered by disease, the whole organ being pushed

upwards or downwards by intra-abdominal or intra-thoracic conditions respectively, or its shape altered by conditions affecting the organ itself.

The gall bladder is bound to the lower surface of the right lobe of the liver by peritoneum, which covers its inferior surface and free end, but not its liver surface. The fundus, which usually projects beyond the margin of the liver, touches the anterior abdominal wall in the angle formed by the ninth costal cartilage and the right linea semilunaris.

The cystic duct is one to one and a half inches long, with a diameter about half that of the hepatic duct. It runs upwards, backwards, and inwards, to join the hepatic duct at an acute angle. Near the gall bladder the mucous membrane of the duct is thrown into spiral folds. The common bile duct, formed by the junction of the cystic and hepatic ducts, is about three inches long, and runs down in the right free margin of the gastro-hepatic omentum, lying to the right of the hepatic artery and in front of the portal vein. In this position it forms one of the anterior boundaries of the foramen of Winslow. The common bile duct next passes behind the first part of the duodenum and then between the head of the pancreas and the second part of the duodenum, where it meets and joins with the pancreatic duct or the duct of Wirsung. The two open together at the summit of the papilla of Vater, on the inner part of the posterior wall of the second part of the duodenum. The duct passes very obliquely through the wall of the duodenum, in which there is an increase in the size of its lumen, the actual opening being again small. For this reason stones are apt to lodge in the wall of the duodenum.

FIG. 137.—DIAGRAM OF THE BILE PASSAGES.

Hydatids

The relief of this condition by puncture or electrolysis is not only insufficient, but often dangerous from the wounding of large veins or the escape of the cyst contents and the dissemination of the disease throughout the peritoneal cavity.

For these reasons tapping and electrolysis have been wholly replaced by the open method of operating.

Position.—The patient lies on the back, the surgeon stands generally on the right side. The position will vary with the situation of the swelling.

Operation.—An incision about three inches long is made vertically over the most prominent portion of the swelling below the costal margin. The peritoneum is opened, the finger introduced, and the cyst explored. As a rule, no adhesions are formed, but if such are found, the wound should be enlarged in their direction, or a new incision made over them, the old wound being closed at once. The cyst wall is smooth, and often very tense, so that it cannot be pulled up into the wound. The general peritoneal cavity is packed off with gauze, and the margins of the wound pressed against the wall of the cyst to prevent infection of the peritoneum from fluid escaping between the cyst wall and the edges of the wound. The cyst is now tapped with a trochar or aspirating needle, and some of the fluid drawn off until the cyst wall is lax enough to be pulled up into the wound. The trochar is withdrawn and the hole in the cyst secured with a pair of artery forceps. The packing is removed from round the cyst and the cyst wall stitched to the parietal peritoneum, a few of the sutures passing deeply into the muscles to insure fixation. When the fixation is complete, so that no fluid can pass into the general peritoneal cavity, the cyst is laid fully open, and its fluid contents removed, the patient being, if necessary, rolled on his side to facilitate the process. The endocyst, which is the scolex-bearing lining of the cyst, may come away at once, but often does not separate till a later date. The interior of the cavity is flushed and then dried, so as to remove as far as possible all the daughter cysts which may be present. The margins of the abdominal incision are drawn together with a few deep sutures placed at either end of the wound. A large drainage tube is put in, and an ample dressing applied.

The above operation may be done in two stages, an interval of some days intervening between them. After the cyst wall has been exposed and stitched to the anterior abdominal wall three or four days are allowed to elapse so that adhesions may form, thus obviating all risk of the peritoneum being contaminated with hydatid fluid. Should the peritoneum become infected with scolices from the cyst contents, secondary hydatids will probably form. After an interval of several days, the second stage, consisting in the evacuation of the cyst, may be carried out without an anæsthetic.

After-treatment.—This is often tedious, as the cavity, if of large dimensions, sometimes takes a long time to close, during which time strict cleanliness must be exercised to prevent infection of the interior.

As a rule a great deal of bile escapes by the fistula. The wound should be dressed every day and flushed out with some weak antiseptic. At a variable date the endocyst comes away, if it has not done so at the operation.

Abscess of the Liver

The opening of an abscess of the liver which can be felt through the anterior abdominal wall, differs in no way from the opening of a hydatid cyst in the same position. In both cases the same care is needed to prevent contamination of the peritoneal cavity. As in the case of the hydatid cyst, the abscess may be dealt with in two stages. If the abscess is situated near the upper surface of the right lobe of the liver, its exact position is located by means of an aspirating needle of wide bore. A good deal of suction must be used, as the pus is often very thick. The operation should take place immediately after the pus has been found, so that there will be no leaking along the track of the needle.

As a rule, it is necessary to resect a portion of the eighth or ninth ribs in the mid-axillary line. As soon as the pleura is exposed it is stitched all round to the diaphragm, so that there will be no leakage into the pleural cavity later, when the abscess is opened. The diaphragm is next divided and the liver, as a rule, is found attached by adhesions to its under-surface. The abscess is freely opened and drained.

Occasionally it is found necessary to resect a portion of the eighth or ninth costal cartilages in front in order to reach the front of the upper surface of the right lobe. In this case the peritoneal covering of the liver is sewn to the parietal peritoneum to shut off the general peritoneal cavity.

OPERATIONS ON THE BILE PASSAGES

The indications for operations on the bile passages are nearly always the signs and symptoms of obstruction to the ducts either by stones or growth.

Gall stones may be solitary, of large size, and chiefly composed of cholesterine ; or great numbers of small stones may be present composed of cholesterine mixed with a large amount of bile pigment and lime salts. Stones composed of pure bile pigment or lime salts are rarely met with.

The stones may be found in the hepatic ducts, but are usually formed in the gall bladder, and from there pass into the cystic and common ducts. They may give rise to symptoms in any of the three situations. Jaundice is only present if the stone causes obstruction to the flow of bile. From anatomical considerations the stone is most likely to lodge at the neck of the gall bladder or at the diverticulum of Vater, the dilatation in the lower end of the common duct as it passes through the wall of the duodenum.

The presence of stones is liable to set up any of the following conditions :—

1. Empyema and gangrene of the gall bladder.
2. Suppurative cholangitis.
3. Chronic catarrh of gall bladder, bile and pancreatic ducts.
4. Phlegmonous cholecystitis.
5. Abscesses round the gall bladder and bile ducts.
6. Adhesions to neighbouring organs.
7. Malignant disease of the gall bladder or pancreas.
8. A large stone may block the small intestine and cause obstruction.

Previous to the operation it is in many cases impossible to tell what condition is present, the surgeon must therefore be prepared to deal with any eventuality which may arise, for the first part of the operation must often be looked upon as an exploratory incision.

Patients suffering from jaundice always bleed excessively. Their blood does not coagulate as readily as that of normal people. To lessen the loss of blood, thirty grain doses of calcium chloride may be given every four hours for a few days previous to the operation.

Instruments.—In addition to the ordinary instruments for abdominal work, the following are required : special forceps and scoops to remove the stones, trocar and canula or aspirating needle, a blunt-pointed flexible probe.

Position.—The patient lies with a sandbag placed under the small of the back to open out the costal angle and bring the structures nearer the surface. The surgeon stands on the right side with the assistant opposite.

Operation.—An incision is made in the upper part of the right linea semilunaris, or over the prominence of any tumour which may exist (see Fig. 91, B). This incision may be enlarged by transverse cuts, inwards at its upper end, outwards at its lower end, whichever seems most needful. Another incision often used is one starting at the level of the tip of the ninth costal cartilage

and passing downwards and outwards parallel to the costal margin. This gives excellent access, but is very damaging to the neuro-muscular structures of the abdominal wall. The peritoneal cavity is opened, the region explored with the fingers, and the further procedure determined upon.

1. Cholecystostomy

If the gall bladder is found to be at fault, it should be carefully packed round with gauze and drawn up into the wound. If greatly distended with fluid, it must be aspirated first and then drawn up and secured with stitches to the margins of the upper part of the incision. If very dense adhesions are met and the bladder is bound down, careful packing must be relied upon to prevent infection of the peritoneum. The gall bladder is then opened between forceps and the contents swabbed out. Stones, if present, can be removed with forceps, small spoons, or scoops, aided by the finger introduced into the abdominal cavity. Stones impacted in the neck of the gall bladder are especially difficult to dislodge, they may either be removed with the help of special forceps, or crushed through the walls of the duct between the finger and thumb, or by forceps, the blades of which have been protected with rubber. Attempts to force the stone on into the duct are not likely to meet with success, and may result in laceration of the duct. When all the stones have been removed a flexible probe should be passed along the duct to make sure that none have been overlooked. In the case of a single stone it is well to examine it for facets indicating the presence of other stones somewhere in the region. The operation is completed by suturing the lower end of the wound, after having made sure that the gall bladder is firmly secured to the upper part. If the bladder cannot be brought to the surface, a drainage tube may be passed into its cavity and well packed round with gauze, or an attempt made to tack down the parietal peritoneum to the margin of the opening in the gall bladder, or a passage may be formed for the escape of bile by sewing the upturned omentum in position round the drainage tube.

2. Cholecystotomy

This is the same operation, with the difference that instead of allowing the bile to drain externally, the incision in the gall bladder is closed up with sutures after the removal of the stones. This is accomplished by passing a continuous row of sutures through the whole thickness of the wall of the bladder, and then inverting

this suture line with a row of continuous Lembert sutures passed through the serous and muscular coats only. The operation is not so safe as cholecystostomy, and cannot be done if the walls of the gall bladder are softened and inflamed.

It is difficult to make sure that the ducts are not blocked lower down by a stone, or a portion of a stone, which has not been removed, and, if such is the case, the bladder will soon be distended with bile, and the risk of the stitches giving will be great.

3. Choledochotomy or Choledocholithotomy

These are the names applied to the operation for the removal of stones from the bile ducts by direct incision through the walls of the ducts.

The position of the stone in the duct having been made out the wound in the abdominal wall is held open with wide retractors, and the general peritoneal cavity protected with swabs. The adhesions, which are often numerous, are gradually broken down or divided between artery forceps. The duct containing the stone is brought as near the surface as possible and a small incision made in the long axis of the distended part of the duct, just above the stone. Preparation must be made for the gush of bile which follows the opening of the upper and dilated portion of the duct. The stone is then grasped with forceps and removed. After the removal of the stone a probe must be passed in both directions along the duct to make sure there is no other stone left *in situ*. Special attention should be paid to the lower part of the duct and the stone itself carefully inspected for the presence of facets. If no other stone can be found, the wall of the duct is sewn up with fine needles, a drainage tube passed down to the site of suturing, and this packed round with gauze, or the omentum brought up and sewn in position round the tube to prevent general infection of the peritoneal cavity. The abdominal wound is then closed in its upper part.

4. Cholelithotrity or Choledocholitripsy

These are the terms applied to the method of removing stones from the bile duct by crushing them through the wall of the duct either with the finger and thumb, or with forceps, the blades of which are guarded with rubber. The method is only suitable for small and soft stones, as the walls of the duct may be very seriously injured in the attempts to crush hard stones, ulceration and subsequent leakage occurring. It is recommended that if this procedure be adopted a cholecystostomy be at the same time

performed and the debris washed down the ducts by syringing through the gall bladder.

5. Transduodenal Choledochotomy

If the stone is impacted in the lower part of the duct and cannot be reached above the level of the duodenum through the gastro-hepatic omentum, as in the cases above considered, it must be approached from the lower end of the duct. To reach this the abdominal wound will probably need enlarging. The edges are then well retracted and the intestines packed out of the way. The second part of the duodenum is defined and an incision made in its anterior wall. The incision may be either longitudinal or transverse, the latter being parallel to the line of the vessels. The intestinal contents are swabbed out and the posterior wall of the duodenum brought into view. The position of the stone is ascertained through the posterior wall of the duodenum. The common opening of the bile and pancreatic ducts at the apex of the papilla is then slit up, a pair of sinus forceps passed up and the stone removed. The gush of bile must be expected and rapidly dealt with by sponging. A probe is then passed up the duct to ensure its patency. The wound in the anterior wall of the duodenum is then closed, and the abdominal wall sewn up with or without drainage.

6. Cholecystectomy

Complete removal of the gall bladder may be necessary—(1) in some cases of empyema of the gall bladder where the walls are ulcerated and destroyed ; (2) in stricture of the cystic duct and consequent dilatation of the bladder ; (3) in persistent mucous fistula consequent on operations on the cystic duct ; (4) after the removal of stones from the bladder where the walls are so shrunken and bound down that drainage is difficult ; (5) in carcinoma of the gall bladder.

The intestines are well retracted and packed off, the adhesions which surround the bladder are gently detached and the bladder freed from the under-surface of the liver. The walls of the gall bladder are often very much thickened by the chronic inflammation, but may be softened and friable and difficult to deal with. When the gall bladder has been freed as far back as the cystic duct, clamps are applied and a ligature is passed and tied between the forceps and the cystic duct cut short, its end is then buried by sewing the peritoneum over it. Care must be taken

not to include the hepatic or common duct in the grasp of the ligature. If troublesome oozing takes place the wound must be firmly packed. The abdominal wound is closed in the upper part, the lower part being left open for drainage.

7. Cholecystenterostomy

This is the operation for anastomosing the gall bladder with a portion of the intestine. The chief indications for this operation are—

1. Obstruction of the common duct due to the presence of an impacted and irremovable calculus, or to cicatricial contraction, causing chronic jaundice with intense itching of the skin.

2. Stricture of the cystic duct where cholecystectomy is not advisable.

3. Persistent discharge from a biliary fistula which shows no sign of closing, and which, by its constant discharge, causes ulceration and rawness of the skin round the opening.

4. Chronic pancreatitis.

5. Carcinoma of the head of the pancreas invading or occluding the duct.

The anastomosis may be made between the gall bladder and the duodenum or first part of the jejunum, or even the hepatic flexure of the colon. The fistula, if one exists, is freed from the abdominal wall in the same manner as described in dealing with fæcal fistulæ. The duodenum or jejunum is brought up into the wound and the general peritoneal cavity packed off. The gall bladder is then anastomosed to the intestine by a lateral anastomosis. The fixation may be effected by sutures or Murphy's button. The wound is then partially closed, and a drainage tube left in for twenty-four hours.

After-treatment.—The after-treatment in operations on the bile passages where a fistula has been formed, consists in keeping the wound aseptic and attending to the condition of the skin in this region. The length of time that the fistula discharges will vary. If the obstruction to the flow of bile through the common duct is removed, then the fistula should close in two or three weeks. If the common duct is occluded the flow will continue until the obstruction is removed, and in persistent cases some further procedure is called for, either to remove the obstruction or to direct the flow of bile into the intestine by anastomosis.

RECTUM AND ANUS

Anatomy.—The rectum is the dilated portion of the large intestine which intervenes between the pelvic colon above and the anal canal below, it therefore extends from the third sacral vertebra to a point one inch beyond the coccyx. It is totally devoid of a mesentery, though in the upper part it is covered at the sides and in front with peritoneum, which gradually leaves the sides and then the front of the bowel to be reflected on to the back of the bladder in the male, and on to the upper part of the vagina in the female. The point at which the peritoneum leaves the front of the rectum is situated in the adult three and a half to four inches from the anus, and about one and a half inches above the base of the prostate. The relations of the rectum are : Laterally, above, the contents of the pararectal fossa, the pelvic colon, and small intestine ; below, the levatores ani and coccygei muscles, with the utero-sacral ligaments in the female. In front, in the male, the rectum is separated from the back of the bladder above by the recto-vesical pouch and its contents, the pelvic colon, and ilium, to within three and a half inches of the anus, below this only loose cellular tissue separates it from the external trigone of the bladder, which is bounded laterally by the converging vasa deferentia and vesiculæ seminales, the posterior surface of the prostate, at the tip of which a sound in the membranous urethra may be felt. In the female, the rectum is separated from the back of the uterus and upper part of the vagina by the pouch of Douglas and its contents to within three inches of the anus ; below this point it is connected with the posterior wall of the vagina, loosely above but more closely below. In the child the peritoneal reflection reaches relatively lower than in the adult, being placed opposite the base of the prostate.

Behind, the rectum lies against the anterior surface of the sacrum and coccyx, and below these on the anococcygeal body in the posterior part of the floor of the perineum. The lymphatics pass up posteriorly, lying with the glands in the hollow of the sacrum.

The rectum is curved in an antero-posterior direction as it lies in the hollow of the sacrum and coccyx, it also curves laterally in a zig-zag manner. These lateral flexures cause the mucous, sub-mucous, and part of the muscular coats to project into the lumen of the tube, and form folds which are known as the valves of Houston. These valves are situated two on the left and

one on the right side, the lowest one on the left side is about three inches from the anus. In these folds the point of an instrument may be caught giving the impression of a stricture. The anal canal is one to one and a half inches in length, and passes downwards and backwards to the exterior from the lower part of the rectum, with which it forms an angle of 45 degrees. The canal is surrounded by the external and internal sphincters. The upper edge of the latter can be felt with the finger as a ridge at the upper limit of the canal. In the upper part, the anal canal is also clothed by fibres of the levator ani, which mingle with those of the internal sphincter. On each side is the ischio-rectal fossa full of fat. Behind, is the ano-coccygeal body. In front, in the male, is the bulb of the urethra and base of the triangular ligament, while in the female the canal is only separated from the vagina by the triangular-shaped perineal body. The mucous membrane of the rectum is thicker and more vascular than that of the colon, and owing to the loose character of the submucous tissue, it is thrown into numerous folds when the gut is empty. It is this looseness of the sub-mucous tissue which allows the prolapse of the mucous membrane. In the anal canal the upper half only is covered with mucous membrane, which is here thrown into longitudinal folds, the columns of Morgagni. The base of each column is connected with that of its neighbours by a small fold forming an anal valve. Below the level of these anal valves the canal is lined by modified skin.

Vessels.—The arteries of the rectum and anus are the superior, middle, and inferior hæmorrhoidals and twigs from the middle sacral. Of these the first is a single vessel, the others are usually represented by one or more twigs on each side. The superior hæmorrhoidal artery is the terminal branch of the inferior mesenteric, it reaches the rectum through the pelvic meso-colon, and breaks up into two branches which run down one on each side of the bowel. These, in turn, break up into secondary branches which pierce the muscular coat of the rectum, and run down underneath the mucous membrane to form anastomotic plexuses with the other hæmorrhoidal vessels in the columns of Morgagni. The middle hæmorrhoidal arteries, one on each side, are branches from the anterior division of the internal iliac, they chiefly supply the anterior wall of the rectum and anastomose freely with the other arteries. The inferior hæmorrhoidal arteries, two or more on each side, are derived from the internal pudic and reach the lower part of the anal canal by passing across the ischio-rectal fossa, they supply the lower part of the back of the rectum and anastomose with neighbouring vessels.

The lower part of the rectum and the anal canal are richly supplied with veins which form tortuous vessels in each column of Morgagni, where they have sinuses as large as a pea. The tortuous vessels communicate below with the inferior hæmorrhoidal veins, and so with the iliac system, above with the superior hæmorrhoidal vein, and therefore with the portal system. As the vessels pass upwards their relations are the same as those of the superior hæmorrhoidal artery.

Preparation of the Patient.—Before operations on the rectum and anus it is essential that the lower bowel should be emptied. For some days previously the patient should have only simple food which leaves little residue in the intestine. Castor oil is given to evacuate all the intestinal contents. A course of intestinal antiseptics may be given, such as salol, beta-naphthol, or salicylate of bismuth. Shortly before the operation a copious enema of warm water is injected, and care taken to see that it is all returned. In the larger operations repeated injections are needed to render the bowel clean. The success or failure of the attempt to obtain rapid healing of the larger wound depends largely on the nature of the bowel contents at, and immediately after, the operation.

Fissure in Ano

The operation to relieve this painful condition is simple in the extreme. The patient is anæsthetized and placed in the lithotomy position. The two thumbs of the operator are inserted into the anus, and the sphincter stretched by slowly and forcibly separating them. When stretching is complete the sphincter will be felt to yield, and on withdrawing the thumbs will not again contract. The prominent tissue at the lower end of the fissure, which sometimes forms a sentinel pile, is seized and cut off. In many cases this is all that is needed. In the majority of cases, however, it is wise to deepen the fissure with a knife, so as to expose the superficial fibres of the external sphincter, some of which may even be divided, and then to cut away the unhealthy edges of the fissure with scissors.

Fistula in Ano

The chief varieties of fistula are :—

1. The complete fistula, in which there is both an external opening on the skin and an internal opening into the bowel. From this track blind extensions may pass upwards or outwards ; or the track may surround the bowel, a second opening

on the skin being present on the opposite side of the anus, constituting the horseshoe fistula.

2. The blind external fistula is a track which opens on the skin surface only, and has no communication with the interior of the bowel.

3. The blind internal fistula has an opening only into the lumen of the gut, and none on the cutaneous surface.

The situation of the internal opening is usually less than half an inch from the anal margin, and may be detected as a depression by the finger or seen with the speculum.

In connection with these three varieties of fistula side-tracts may form, which may burrow in all directions, up under the mucous membrane, through the levator ani or into the ischio-rectal fossa. If a track more or less surrounds the anus it is known as a horseshoe fistula, this is usually found behind and at the sides of the anus.

Many external openings may form from the blockage of side-tracts and the bursting of the abscess formed, but the internal opening always remains single, and usually is at the back of the anus.

Instruments.—Grooved director, curved and straight bistouries, scissors, artery and dissecting forceps, sharp spoon, and ligatures.

Position.—The patient is put up in the lithotomy position, the surgeon being seated at the foot of the table.

Operation.—In the case of a complete fistula a probe is inserted at the skin opening, and the end made to project into the lumen of the bowel, where it is felt with the forefinger of the left hand; in the case of an external blind fistula the end of the probe is felt underneath the mucous membrane, the place where this feels thinnest is sought, and the probe pushed through on to the finger and the end hooked down out of the anus. With a blind internal fistula the proceeding is reversed, and the probe, suitably curved, entered from the lumen of the bowel and made to project externally under the thinned skin. With a curved bistoury or the scissors, the tissue which lies on the probe is divided, thus laying open the whole track from the skin to the mucous membrane. The fistula is cleaned and all the granulations scraped off, all extensions sought for and laid open, all hard scar tissue removed, and unhealthy skin and mucous membrane cut away. If piles exist they should be dealt with at the same time. If there is a horseshoe fistula present it is unwise to divide the sphincter in two places, as great loss of power is likely to follow such a proceeding. The fistula should be opened up in the way described, the sphincter being divided

once only, the track round the posterior part of the anus is then laid freely open and scraped. When the bleeding has been arrested the parts are packed with a thin strip of gauze, and a morphia suppository placed in the rectum.

After-treatment.—The dressing should be changed at the end of twenty-four hours, and after that not till the bowels open on the third or fourth day. The parts must be well washed when the bowels have acted. The wound should be carefully dressed till healing is complete, the cleanliness of the part must be attended to, and any tendency for the superficial parts of the wound to heal before the deeper must be checked.

HÆMORRHOIDS

Indications.—The indications for the removal of piles are the continual loss of blood, in spite of the most careful treatment, the persistent tendency for the piles to come down on any exertion, and the lowering of the general health of the patient by the constant irritation of their presence. Careful examination must be made of the liver, the heart, and the kidneys.

Methods.—Of the many methods designed for dealing with this condition only four need be fully described—

1. Scissors and ligature (*Salmon's operation*).
2. Clamp and cautery.
3. Whitehead's operation.
4. The suture method.

Position.—The patient is put up in the lithotomy position with the hips at the end of table. The surgeon sits facing the patient's perineum.

1. Scissors and Ligature

Operation.—The surgeon begins by stretching and temporarily paralysing the sphincters. This is done by passing the two thumbs into the anal canal and exercising steady pressure by separating the thumbs, the fingers grasping the ischial tuberosities on each side. Steady pressure is kept up for about two minutes, when the sphincters will be felt to give way, and the anus will remain patulous, and have no tendency to contract. The piles are thus brought into view. Each pile is grasped with artery forceps. The forceps should be applied to all the piles at the beginning, as later the smaller piles may become obscured by blood and overlooked. The most posterior pile is selected and pulled

forwards, while the muco-cutaneous junction at the lower side of its base is snipped through together with the mucous membrane along its sides. The mucous membrane at the upper end of the pile is left untouched, as the main vessels enter and leave it at this point. When the pile has been freed in this way a stout silk ligature is applied and tied tightly round this attached neck. The knot should lie in the lumen of the bowel, and the ends should be left long. If the pile is large a small piece of its free end may be removed, but it should not be cut anywhere near the ligature, so that there is no chance of the ligature slipping over the end. Each pile is taken in turn and treated in the same way. Some surgeons prefer to transfix the neck of the pile before tying the ligature. There is, however, no necessity to do this if the pile is not cut short later; moreover, in transfixing a large vein may be pierced, and the hæmorrhage difficult to stop. When all have been dealt with a search is made for any vessels still bleeding, and these are secured. The ligatures applied to the piles themselves are left hanging out of the anus, they separate after about a week.

2. Clamp and Cautery

The patient having been put up in the lithotomy position, and the sphincter stretched, the piles are caught in forceps as before. To the base of each pile a narrow clamp is applied as tightly as possible, so as to crush the stump between the blades. All the clamps should be applied before the cautery is used. The old-fashioned, broad Smith's clamps are not recommended, as they are too broad and more than one cannot be conveniently used at once. A Paquelin's cautery, heated to a dull red heat, is made to sear the portions of the pile beyond the clamp so that nothing but a narrow charred stump remains when the clamp is removed later. All the piles are cauterized in turn, and then the clamps are cautiously removed so that the charred edges are not torn apart in separating the blades of the clamps. If the clamps are removed too soon, or if oozing takes place, it is extremely difficult to reapply the clamp to the shortened stump.

3. Whitehead's Operation

This operation consists in the removal of the whole pile-bearing area of mucous membrane from the lower end of the bowel.

Operation.—The patient is placed in the lithotomy position, and the sphincters dilated as before. The muco-cutaneous junction just inside the anus is caught with artery forceps in four places—in front, behind and at the two sides. On drawing on any two adjacent forceps the muco-cutaneous junction will become stretched out into a straight line. The muco-cutaneous

junction is divided by carrying the knife from one forceps to the next all round the bowel. The sub-mucous tissue is opened up, and the mucous membrane separated from the wall of the anus either with the finger or a blunt-pointed pair of scissors. It is well to commence the separation at the posterior part of the anus, and work round the sides to the front, so that the dissection is not obscured by blood. In this way a tube of mucous membrane, with its blood supply, is pulled down out of the anus; any points of resistance are divided, and the tube separated for at least a quarter of an inch above where it is to be divided. The tube is then cut across in successive sections, beginning in front, each section being sewn to the skin of the anal margin as soon as it is cut across, so that the bowel is fixed and the bleeding stopped by the same suture. This is continued till the whole circumference of the bowel has been dealt with.

4. The Suture Method

In this the piles are pulled down in turn and their base grasped in a clamp applied in the long axis of the bowel. The free part of the pile is then cut off. The upper part of the mucous membrane is transfixed just on the bowel side of the clamp to secure the main vessels, and the cut surfaces are sutured together with a continuous suture, and the clamp removed. Each pile is dealt with in the same way. Some recommend the suture be applied on the distal side of the clamp without cutting away the pile. When the suture is drawn tight and the clamp removed they claim that the pile is destroyed.

After-treatment.—In all operations for piles before the patient leaves the table the finger should be inserted into the rectum to make sure that the lumen of the gut is sufficiently free. The parts are then smeared with carbolized vaseline and a perforated rubber tube inserted for about six inches to allow for the passage of flatus and to guard against the danger of concealed hæmorrhage. A morphia suppository may be inserted at the same time. Pads of gauze and then of wool are placed on each side of the anus, the tube projecting between them; over tube and all a piece of wool is placed and fixed in position by a T-bandage. Any bleeding which takes place now will escape along the tube into the superficial layers of the dressing, and so can be noticed at once without disturbing the patient. The painful spasms which occur during the first few days should be relieved by morphia. An aperient should be given on the evening of the third or fourth day, followed next morning by an oil enema given through a catheter, which can be inserted into the rectum without causing pain. The sutures on the piles and the sloughs from the cautery

come away after the seventh day, and the patient can get up after the tenth day.

The **dangers** of the operation are sepsis, hæmorrhage, and stricture. Sepsis is avoided by attention to the bowels before and after the operation, the provision of a free escape for all discharges, and cleanliness. Hæmorrhage is to be feared if the vessels are not properly caught. Fatalities have occurred from this cause, as the bleeding has taken place into the bowel, which may become quite full of blood before the exsanguined condition of the patient attracts notice. This cannot take place if, after the tying of the ligature, the pile is left uncut. Bleeding can never take place unnoticed into the rectum if a tube is inserted. Stricture is avoided by passing the finger into the bowel at the time of the operation, and again before the patient is discharged as cured.

Comment.—Of these operations that with the ligature is the simplest and best. It can be applied to all cases, and can almost be said to be devoid of risk. Free drainage is provided, the vessels are secured, and stricture is very unlikely to follow. The clamp and cautery is only suitable to cases in which the piles are few in number. There is a risk of hæmorrhage, and should this occur from the stump of one pile, the edges of the other stumps are very liable to come apart in the efforts to see and catch the bleeding points, which are particularly difficult to catch on a seared surface. With the simple suture, if sepsis gains access to the sub-mucous tissue along the sutures, there is no drainage provided. The claim that it is a painless procedure is not justified. Whitehead's operation is more extensive than the others, and needlessly severe for the majority of cases. It is excellent for those cases in which the whole circumference of the bowel is in a varicose condition. The danger of the operation is the formation of a stricture, and great attention must be paid to the after-treatment to prevent this.

PROLAPSE OF THE RECTUM

This is usually divided into the complete and the incomplete varieties. In the latter, there is a protrusion of the mucous membrane only, in the former the mucous membrane drags down the muscular wall of the bowel, which in turn may pull down the reflection of the peritoneum. Of these two varieties the incomplete is by far the more common.

Indications.—Failure of other simpler treatment to keep up the protrusion; large size of the prolapse; thickening and ulceration of the mucous membrane or hæmorrhage from its surface; relaxation of the sphincters with incontinence of the fæces; general health of the patient suffering from the worry and constant annoyance.

Methods.—The following methods will be described:—

1. Cautery;
2. Excision;
3. Ventral fixation.

1. By Cautery

The patient is placed in the lithotomy position. The sphincter is dilated and the loose mucous membrane pulled down, the actual cautery, or Pacquelin's cautery heated to a dull red-heat, is then applied along the whole length of the protrusion in a straight line about a quarter of an inch wide, three or four such lines may be marked with the cautery at equal distances round the circumference of the gut.

The burn should sear but not absolutely destroy the mucous membrane. The prolapse must be returned before great swelling takes place.

2. By Excision

(1) *Removal of lozenge-shaped portions of Mucous Membrane and Skin*

If the prolapse is not very extensive, diamond-shaped pieces of skin and mucous membrane may be excised so as to narrow the lumen of the anus, and to remove some of the redundant mucous membrane as well as to bind it down by the subsequent contraction of the cicatrix. The anal sphincter is stretched and the prolapse brought down. With a knife, a diamond-shaped portion of the surface is marked out in the long axis of the gut, the lower end of the diamond extending on to the skin surface. This area is now dissected up, the vessels tied, and the manœuvre repeated on the opposite side of the gut, until three or four such pieces have been removed. The edges are then stitched together so as to convert the diamond-shaped surfaces into linear incisions which lie in the long axis of the gut and extend on to the skin surface. When the margins are accurately sutured the parts are returned. Care must be taken not to break down the stitches by too early examination.

(2) *By complete Removal of the Mucous Membrane*

The sphincter is stretched and the prolapse brought fully down out of the anus. The junction of the skin and mucous membrane is cut round with a knife and a cuff of mucous membrane turned down until the prolapse is doubled in length and only a raw surface is seen. The bleeding is trifling and easily controlled. The forefinger of the left hand is now inserted into the lumen of the gut as far as the level of the anus so as to make out by the feel of the parts if any of the anterior muscular wall of the rectum is pulled down, the risk of there being a peritoneal bag in front of the gut being kept in mind. The tube mucous membrane is cut through in stages, each portion being sutured to the skin margin with catgut as soon as it is divided. If the prolapse is complete and there is a pouch of peritoneum pulled down in front of the gut, care must be exercised in opening the pouch, as it may contain a coil of small intestine. As soon as the wall of the gut is cut through and the peritoneum is opened, the cavity must be packed off with gauze until the limits of the sac are ascertained and then the edges are closed with a continuous suture, the rest of the bowel being divided by stages until the whole of the prolapsed portion is removed, the vessels being caught and twisted as they are divided.

3. Ventrifixation or Colopexy

This operation is done in the complete forms of prolapse to avoid opening the peritoneum in a septic wound, where it is feared that the recto vesical pouch of peritoneum is pulled down in front of the bowel.

Position.—The patient either lies on the back or in the Trendelenburg position, with the pelvis above the level of the head. The surgeon stands on the left side of the patient.

Operation.—An incision about three inches long is made on the left side above Poupart's ligament as for inguinal colotomy. The peritoneum should be opened by splitting the muscles in the direction of their fibres. The fingers are passed into the abdominal cavity, and the pelvic colon pulled into the wound. The gut is passed through the fingers, the lower end being pulled out of the wound while the upper end is pushed back into the abdomen, exactly the reverse of the procedure in inguinal colotomy. When no more gut can be drawn out of the wound the result of traction on the mucous membrane and gut wall of the rectum is noted by the finger of an assistant introduced into the anus. A piece of the pelvic colon is selected which can be attached without tension to the anterior abdominal wall. The mesentery of the portion selected is then fixed with sutures to the parietal peritoneum, the sutures embracing a considerable portion of the thickness of the abdominal wall and the mesentery close to the intestine. Three or four such sutures should be

passed. If the sutures have been made to embrace both sides of the wound they can be used to fix the gut, and at the same time to approximate the deeper layers of the abdominal wall. The abdominal incision is then completely closed. It is important not to allow any traction on the sutures by a loaded colon until the adhesions are firmly established, the bowels should be kept well open with mild aperients for some weeks after the operation.

RECTAL POLYPUS

Operation.—This is usually performed in the same way as the operation for the removal of piles with the ligature; the sphincter is stretched, the polypus brought down, the base transfixed, ligatured, and cut short. An examination should be made to see if there is not more than one polypus present. This should be done by means of a speculum, as a polypus may be seen when, on account of its softness, it escapes detection by the examining finger. Very often as the polypus is pulled down with forceps the stalk gives way and the head comes off, the stalk being at once retracted into the bowel; if such an accident occur the bowel must be examined with a speculum and the stalk found, transfixed, and ligatured. Serious hæmorrhage may take place into the lumen of the gut if the torn stalk of a polypus is not secured.

EXCISION OF THE RECTUM

Indications.—Excision may be carried out for: (1) simple stricture of the rectum low down, associated with fistulæ or ulceration; (2) malignant disease of the anus or rectum. Fortunately the vast majority of malignant growths of the rectum are situated well within reach of the finger, *i.e.* within three or four inches of the anus. Glandular complications and infiltration of the surrounding tissues, as estimated by the fixity of the bowel, are, if marked, a contra-indication to a radical operation. Glandular invasion is said to be a late complication in rectal disease, but it must be remembered that the disease is insidious, and is often in an advanced stage before it is diagnosed. The points at which it is important to estimate the amount of fixity of the bowel are the membranous urethra and prostate, or the cervix and ligaments of the uterus according to the sex. In the male the fascial sheath of the prostate seems to form a bar

to the early extension forwards of the disease ; but in the female the posterior wall of the vagina is rapidly attacked.

Resection of the diseased portion of the rectum may be performed by the perineal, sacral, or vaginal routes ; or by a combination of an abdominal with a perineal operation.

Special instruments.—In addition to the ordinary instruments, rectal speculum, sponges and sponge holders, and Paquelin's cautery should be provided. For the sacral operation the ordinary bone instruments will be needed in addition.

Excision by the Perineal Route

Position.—The patient is placed in the lithotomy position. The surgeon is seated facing the patient's perineum.

Operation.—*First stage. The incisions.*—The left forefinger is passed into the rectum and the relation of the coccyx determined ; a curved probe-pointed bistoury is passed along the forefinger and the posterior wall of the bowel, and the soft tissues are divided in the middle line as far back as the coccyx. Two lateral curved incisions are now made, one on each side of the anus, starting from the posterior median incision and passing round the anal margin to meet in front. The exact position of these incisions will vary with the position of the growth, if situated high up in the bowel the incisions should pass through the mucous membrane about a quarter of an inch from the muco-cutaneous junction ; if the position of the growth is low down then the muco-cutaneous junction must be the highest level to which they reach, or the danger of recurrence will be increased.

Second Stage. Freeing the Bowel.—The lateral incisions pass into the ischio-rectal fossa on their respective sides, and are deepened until the levatores ani are met with. These are snipped through with blunt-pointed scissors, commencing behind and working round to the front. The separation of the rectum in front is facilitated, in the male, by passing a large-sized staff into the urethra ; this is held by an assistant in the middle line, while the surgeon's finger guides the scissors. In the female the finger of the assistant passed into the vagina fulfils the same purpose.

The surgeon pulls down the bowel with the left hand, while with the fingers or the scissors he continues to free the attachments in front and at the sides, until he is well above the level of the growth, all bleeding vessels being at once caught and twisted or ligatured. The bowel should be freed at least an inch above the upper limit of the growth.

Third Stage. Excision of the Growth.—The bowel is seized with catch forceps and divided in small sections with scissors at least one inch above the upper limit of the growth, the vessels which run longitudinally in the intestinal wall can in this way be caught at once. The lumen is examined to see that no disease has been left behind. When all bleeding has stopped stout catgut sutures should be passed through the mucous membrane, deeply through the tissues at the side, and lastly through the skin or mucous margin which has been left below. If a ring of mucous membrane has been left it will greatly lessen the tension on the stitches which bring the upper edge of the bowel down to the lower edge. Superficial sutures are then inserted. Unless the sutures are passed deeply they will certainly cut out.

According to Cripps it is useless to insert sutures, as they invariably cut out and cause pockets to form in which sepsis is likely to occur. These objections do not hold in the case of deep sutures which include the levatores ani, as they cannot easily cut their way through the tissues, and they have the advantage of obliterating any pouches which otherwise might form. On the whole, there is so much gained in the rapidity of healing from drawing down the bowel, if only a little way, that the method is worthy of a trial. Bidwell recommends that an incision two inches long should be made on either side of the anal wound, and the flaps dissected up and sutured to the margin of the bowel, the raw surfaces on each side being left to granulate.

Taylor advises if the bowel cannot be brought to the skin margin at the original site of the anus, that "it be drawn backwards in the middle line between the levatores ani and a subcoccygeal anus formed." The other method is to leave the raw surface to granulate and wait for the skin and mucous membrane to grow over it, the subsequent contraction causing the edges of the bowel to be pulled down, this method causes the greatest amount of cicatricial contraction of the lumen afterwards.

After-treatment.—This aims at the prevention of sepsis by cleanliness, and the limitation of the contraction by suitable bougies. The wound is dried and a perineal tube ready dressed with lint is passed into the lumen of the bowel. Between the lint petticoat and the tube gauze is packed, and by its pressure prevents oozing, while the tube allows the passage of flatus. The bowels are not allowed to act for a week, the dressing being changed and the parts kept scrupulously clean in the meantime. Signs of contraction are generally seen within a month of the operation, and the use of the rectal bougie should be commenced at once, the bougie being worn for several hours each day. After six to

eight weeks, the time the wound generally takes to heal, if no sutures have been passed, or if they have cut out, the bougie should be passed every other day. Its use may be needed for a year or perhaps longer.

Excision of the Rectum by the Sacral Method (*Kraske's Operation*)

This operation is intended for the removal of malignant growths of the rectum which are situated too high up for removal by the perineal route, and which are too low down or too fixed to be removed by an incision through the anterior abdominal wall. The operation is a very severe one, and only to be undertaken in those patients who have sufficient recuperative power to undergo such a formidable ordeal, and after the advantages and disadvantages of the operation over a palliative colotomy have been put fairly to them.

Position.—Different positions for the operation are favoured by different surgeons. The one commonly adopted is that of the right lateral, where the patient lies on the right side near the edge of the table for the first part of the operation, and just prior to the resection of the gut is placed in the lithotomy position. If the lithotomy position is adopted for the whole operation, the pelvis must be raised by a sandbag placed underneath it, and the thighs well flexed on the abdomen.

The prone position is adopted by some, in which the patient is placed on the face with the pelvis at the foot of the table and the thighs hanging over the end, the foot of the table being raised on blocks. This last posture considerably embarrasses the anæsthetist.

Operation.—This may be divided into three stages: (1) the exposure of the rectum; (2) the removal of the gut; (3) the treatment of the divided ends.

1. *The Exposure of the Rectum.*—A mesial incision is made from the posterior edge of the anus to the third sacral spine, the structures being divided down to the bone. If the growth is not within an inch of the anus the external sphincter is not interfered with. On the left side the edge of the wound is drawn outwards and dissected up, containing the lower portion of the origin of the gluteus maximus, exposing the left side of the sacrum and coccyx, the sacro-sciatic ligament, the coccygeus, the sphincters, and levator ani muscles. If the growth invades the sphincteric region all the soft structures just mentioned must be divided and separated from the left side of the sacrum and coccyx. If the growth does not extend far down the anal

muscles should be interfered with as little as possible. A periosteal elevator is inserted in front of the bone, and the tissues detached from its anterior surface, including the venous plexus and the middle sacral vessels. The coccyx is now removed, the surgeon grasping it with a pair of lion forceps held in the left hand, while with the right the soft structures are divided. Wounding of the bowel is avoided by keeping the edge of the knife turned towards the bone. If sufficient space is not provided by the removal of the coccyx, a portion of the sacrum must also be sacrificed. Kraske's plan was to retract the parts strongly over to the left, and, with a mallet and chisel, to divide the sacrum along a line commencing at the left border of the sacrum on a level with the third posterior foramen, and running thence downwards and inwards through the fourth sacral foramen to the right inferior lateral angle of the bone. By this line the anterior division of the third sacral nerve is preserved intact. The portion of bone is removed, the attachment of the soft parts being divided with the knife in the same manner as the coccyx. Up to this point the bleeding, which has been mainly venous, has been controlled by pressure, and no time wasted in catching any but the few spurting vessels. These are branches of the middle and lateral sacral and hæmorrhoidal arteries ; the bone is clothed on both surfaces by a venous plexus.

By this means about seven inches of bowel are brought into view. If the patient has been lying in the right lateral position, he may, if preferred, be placed in the lithotomy position. The bowel is now gently freed at the sides by the fingers, which by palpation of the wall determine the extent of the disease. The fingers work round the bowel towards the anterior aspect, the ease with which this is done depends on the amount of matting together of the surrounding tissues. A staff should be inserted into the urethra if the patient is a male, the better to protect the urethra and prostate from injury ; in the female the finger inserted into the vagina will prevent injury to the posterior wall of that organ. The complete separation of the rectum anteriorly can only be attained when the bowel is divided, and no forcible attempts to do so should be made prior to that division.

2. *Removal of the Gut.*—The bowel is clamped at least an inch below the growth, and the wall cut through with scissors below the clamp. The clamp will now serve to pull down the lower margin of the bowel, while the separation is completed in front. The separation of the bowel is continued upwards until the reflection of peritoneum from its anterior surface is met. If the growth is low down it may be possible, by pushing up this

reflection, to reach sufficiently high to remove the disease without opening the peritoneum. In other cases the peritoneum must be freely opened in front, the cavity being at once shut off with gauze. The pelvic meso-colon is now separated posteriorly from the anterior surface of the sacrum and the bowel pulled well down into the wound. Clamps are then applied one to one and a half inches above the upper limit of the disease, and the bowel divided between them. Great care must be used to prevent contamination of the wound with bowel contents.

The opening made in the peritoneum is now closed with sutures. All bleeding points are now caught and ligatured.

3. *Treatment of the Divided Ends*,—This will depend very largely on the amount of the diseased bowel removed; if the anus and a portion of bowel above it are left, the upper end of the bowel should be pulled down and an end-to-end anastomosis performed. The anterior and lateral margins of the ends of the gut are joined together with a double row of sutures, the first passing through the whole thickness of the intestinal wall, while the second unites the edges of the mucous coat. The posterior margins are united with a row of sutures which pierce all but the mucous coat, and should be made to invert the walls, although no peritoneum is available. The entire line of the posterior surface invariably breaks down. If the anus and sphincters have been removed the upper end of the bowel is fixed to the upper limit of the wound so as to make a sacral anus.

Other Methods of Dealing with the End of the Bowel.—The bowel may be twisted on its long axis until considerable resistance is offered to the introduction of the finger, and then sutured in this twisted state to the upper end of the wound with superficial and deep sutures. In this way a slight obstruction is made to the outflow of fæces to replace the removed sphincters (Gersuny).

Witzel attempts to make an artificial sphincter by making an incision through the lower edge of the exposed gluteus maximus, drawing the lower end of the bowel through this, and then suturing it to the skin margin at the upper end of the wound.

If more than three inches of intestine had been removed, Paul does not attempt the union of the divided ends, but fastens a glass tube into the upper end with a stout ligature, and then sutures the bowel to the upper end of the wound. This method has the advantage that all fæcal matter is carried away from the site of operation, and all the vessels in the intestinal wall are controlled at once by the one ligature.

Keen performs an inguinal colotomy a fortnight before the

operation, and completely closes the lower end of the bowel with sutures, so that all the fæces for the future must pass by the colotomy wound. The sacral wound being kept aseptic, heals by first intention.

After-treatment.—The wound will require frequent dressings, and should be well washed each time, and thoroughly dried afterwards. The bowels should be confined for at least six days subsequent to the operation, and then allowed to act with the help of an aperient and olive oil enema, the wound being well washed after each motion.

Modifications of Kraske's Operation

The modifications are numerous and aim either at procuring more room by dividing the sacrum higher up or at disturbing the floor of the pelvis as little as possible by performing a temporary resection of the sacrum.

To procure more room Bardenhauer divides the sacrum transversely across at the level of the third sacral foramen. Volkmann and Rose divide the bone transversely just below the fourth sacral foramen and remove the lower portion. Heinecke, for the same reason, divides the sacrum at the level of the fourth sacral foramen, and then divides the lower portion vertically; the two triangular osteo-plastic flaps are turned one to each side while the resection proceeds, and are replaced at the end of the operation.

Rehn and Rydygier use an incision which starts at the posterior superior spine of the ilium and passes down to the tip of the coccyx and thence to the anus; they divide the muscles and ligamentous structures along the left border of the sacrum, thus gaining access to the pelvis. The anterior surface of the sacrum is cleared and the bone divided transversely with a chisel just below the third sacral foramen. The osteo-plastic flap is turned over to the right till the removal of the bowel has been effected, when it is replaced and stitched in position.

Paul recommends the use of a similar osteoplastic flap. He removes the lower portion of the bowel, together with the sphincters; the upper portion is brought out at the upper end of the wound, one corner of the osteo-plastic flap is nibbled away with forceps to give exit to the bowel, the remainder is replaced below the point of exit. The right-angled turn that the gut makes round the cut surface of the sacrum is of service in preventing the incontinence of fæces.

Excision by the Abdomino-Perineal Method

This need only be mentioned shortly, as it is a combination of the operation for the resection of the colon and the formation of an artificial anus with the perineal operation for the removal of the rectum. The method is used in those cases where the growth is difficult to approach by either the perineal or abdominal routes alone. As a preliminary measure a colotomy

should be performed, and the bowel thoroughly emptied; this preliminary colotomy simplifies the operation and shortens the time taken.

1. *The Abdominal Portion.*—The patient is placed in the Trendelenburg position, and the abdomen opened in the middle line below the umbilicus. The hand is inserted, and the possibility of complete removal ascertained; the liver and spleen are examined for the presence of secondary growths, which if they are found, will render any extensive operation unnecessary. The small intestines are packed out of the way and the colon is isolated. A point is chosen some way above the growth where the intestine can easily be drawn to the surface; if a preliminary colotomy has been performed, the point on the colon must be below that level. The colon is divided between clamps. The upper end is wrapped in gauze and laid aside to be fixed in the abdominal wound later to form an artificial anus, or if a preliminary colotomy has already been formed, then the end of the intestine can be closed completely. The lower end of the gut is closed and the end inverted. The mesentery is then clamped and divided so that the inferior mesenteric artery is secured. The peritoneum is divided down the two sides of the sacrum, with small snips of the scissors, which are carried forward on the floor of the pelvis some distance from the bowel to meet in front on the back of the bladder in the male, or on the back of the vagina in the female. The lower portion of the gut, together with all the fat and glands in the meso-rectum, are pushed down from the front of the sacrum. The cut edges of the peritoneum from the two sides are then sewn together over the whole mass, which is thereby completely shut out from the peritoneal cavity.

2. *The Perineal Portion.*—The patient is turned over into the right lateral position. An incision is carried round the anus, and the edges of the skin are sewn over the opening. The incision is then carried back over the coccyx and up the left side of the sacrum. The incision is deepened and the coccyx is removed. If more room is needed a portion of the sacrum is also removed; this, however, is seldom necessary, as all the difficult manipulations have already been carried out from within the abdomen. The wound is deepened and the severed end of the gut found in front of the sacrum, it is drawn down with its fat and glands. The gut is freed from the levator ani at the two sides and from above downwards in front, the usual precautions being taken to avoid injury to the structures in the neighbourhood. There is no fear of infecting the peritoneal cavity at this stage, as that is already shut off. The incisions round the anus

are extended into the ischio-rectal fossæ, and the lower portion of the bowel and the whole of the anal canal are removed.

3. *The Closure of the Wound.*—The perineal wound can be sewn up completely, buried sutures being used for the deeper parts; small tubes are inserted at each end of the wound. The patient is then turned on his back and the abdominal wound closed, if a colotomy has to be formed the upper portion of gut is now fixed in the lower part of the wound. Both wounds should heal by first intention, unless the lumen of the bowel has been accidentally opened into and the perineal wound infected.

Note.—Occasionally it may be possible by removing a piece of the sacrum to bring the upper portion of the bowel down sufficiently to allow it to be fixed in the upper part of the perineal wound. If, however, this portion of the bowel is freed very extensively and much strain is put upon it, sloughing is very liable to occur. If a colotomy has already been made the bowel cannot be brought down. The advantage of a sacral over an inguinal anus is very doubtful, and the latter is much easier looked after by the patient.

Excision of the Rectum through the Vagina

This operation, devised by Campenon and Rehn, aims at resection of the diseased portion of the rectum by laying the cavities of the vagina and rectum into one by an incision straight through the posterior wall of the vagina into the rectum. The incision is carried down so as to divide the sphincters of the anus anteriorly if they are to be removed. The bowel is dissected off the vaginal wall and freed from the hollow of the sacrum; the diseased portion is resected, the peritoneal cavity at the bottom of the pouch of Douglas being opened if necessary. The upper portion of gut is united to the sphincters if they have been left, while if the anus and sphincters have been removed, the gut is treated in the way laid down in resection by the perineal route.

CHAPTER VIII

Operations on the Alimentary Tract (*continued*)

Hernia: Inguinal, Femoral, Umbilical—Strangulated Hernia

RADICAL CURE OF INGUINAL HERNIA

Anatomy.—The inguinal canal by which the cord leaves the abdominal cavity is about one and a half inches long. It is a narrow passage passing almost directly inwards, with a slight inclination downwards and forwards. It begins at the internal abdominal ring, which is situated half an inch above Poupart's ligament, half-way between the anterior superior iliac spine and the spine of the pubis, and ends at the external abdominal ring above the crest and spine of the pubis. The anterior wall of the canal is formed in its whole length by the strong aponeurosis of the external oblique, and in its outer third by the fleshy lower border of the internal oblique. The posterior wall is formed in its whole length by the fascia transversalis, and in its inner third by the conjoined tendon. The floor of the canal is formed in the outer part by the grooved, upturned surface of Poupart's ligament. Towards the inner portion the floor broadens and the abdominal surface of Gimbernat's ligament also takes a part in its formation. The canal is roofed over by the lower margin of the internal oblique muscle arching over to form part of the conjoined tendon. The transversalis muscle takes no part in the formation of the canal except where it helps to form the conjoined tendon, and of this it forms the greater part, for the attachment of the internal oblique only extends along the ilio-pectineal line for half an inch, whereas that of the transversalis extends for fully an inch. It is this strong conjoined tendon which makes up for the weakness of the abdominal wall opposite the external ring.

Hesselbach's triangle is that portion of the anterior abdominal wall bounded by the outer edge of the rectus internally, Poupart's ligament below, and the deep epigastric vessels externally. The course of the deep epigastric artery may be marked out by a

line from the umbilicus to the mid-point between the anterior superior iliac spine and the symphysis pubis. The internal abdominal ring is immediately to the outer side of the deep epigastric artery. Sometimes this triangle of Hesselbach is divided into an inner and an outer half by the obliterated hypogastric artery, so that, looking at the posterior aspect of the abdominal wall in this region, three shallow pouches are seen, an inner and a middle pouch in Hesselbach's triangle, and an outer one to the outer side of the deep epigastric artery. In either of the two first pouches a direct hernia may leave the abdominal cavity; in the outer an oblique or external hernia leaves—the terms direct and oblique indicating respectively whether the hernia pushes its way directly through the structures of the abdominal wall or passes obliquely down the inguinal canal. The terms internal and external, when applied to inguinal

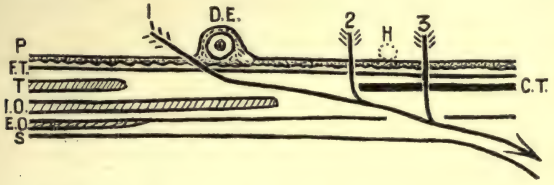


FIG. 138.—DIAGRAM OF THE INGUINAL CANAL.

P., Peritoneum. F.T., Fascia transversalis. T., Transversalis muscle. I.O., Internal oblique E.O., External oblique. S., Skin. D.E., Deep epigastric artery. H., Obliterated hypogastric artery. 1, External, indirect or oblique hernia. 2, Direct hernia through the middle pouch. 3, Direct hernia through the internal pouch.

hernia, denote the relation of the neck of the sac to the deep epigastric vessels. There is no practical use in attempting to distinguish which of the two inner pouches the hernia has left by, but it is of the utmost importance in strangulated hernia to know whether it is of the oblique or direct variety, as on this depends the relation borne by the deep epigastric artery to the neck of the sac.

As the hernia protrudes through the abdominal wall it receives coverings from each of the structures which it pushes before it; these will vary in accordance with the site of the hernia; in the direct hernia they will be from without inwards.

1. Skin and superficial fascia.
2. Inter-columnar or external spermatic fascia.
3. Conjoined tendon (inner pouch only).
4. Transversalis fascia.
5. Extraperitoneal fatty tissue.
6. Parietal peritoneum forming the sac of the hernia.

In the oblique hernia the coverings are identical with those of the cord and are derived from the same structures.

1. Skin and superficial fascia.
2. Inter-columnar or external spermatic fascia.
3. Cremasteric fascia and muscle.
4. Infundibuliform fascia.
5. Extra-peritoneal fatty tissue.
6. Parietal peritoneum or sac of the hernia.

In old-standing cases of oblique hernia the contents of the sac often force the internal abdominal ring into a position immediately behind the external ring, so that it is extremely hard to tell to which variety the hernia really belongs. In such cases the tip of the finger pushing the skin before it into the abdominal cavity may feel the pulsations of the artery to the inner side of the neck, thereby showing conclusively that it is really an oblique or external hernia.

General Remarks on the Operation for Radical Cure

The operation for radical cure aims at—

1. The obliteration of the cavity of the sac; this is brought about by many means, ligature, puckering, or twisting the empty sac. In children this of itself may be sufficient to cure the hernia.

2. Strengthening the abdominal wall at this naturally weak spot. This is done by buried sutures which are so arranged as to narrow the various points of the canal through which the hernia came down. The inlet to the sac may be displaced by suturing the ligatured neck of the sac to another part of the abdominal wall, or the puckered sac may be used as a buffer to prevent the entrance of the hernia into the canal. The canal is generally narrowed by suturing the roof formed by the arching over of the internal oblique, transversalis, and conjoined tendon, down to the floor formed by Poupart's ligament. The external ring is narrowed by sutures approximating the inner and outer pillars. In some methods of radical cure the canal and external ring are completely obliterated and the cord conveyed through the abdominal wall by making a new passage for it. The simpler the operation, the easier it is to perform, and the more closely it follows the anatomical arrangement provided by nature, while at the same time combining the two aims laid down above, the more successful will be the result.

Indications.—1. Cases of strangulated hernia where the general condition of the patient permits of the operation.

2. Cases of irreducible hernia where from adhesion or other cause the hernia can never be completely returned and controlled by a truss. There is always in these cases a fear of strangulation occurring from sudden strain overfilling the hernial sac.

3. Where the patient will not put up with the bother entailed by the use of the truss. In some people, even with the best fitting truss, considerable irritation is caused.

4. Cases which are not controlled by a truss.

5. Cases in which a truss is not suited, as in associated varicocele or partially descended testicle.

6. To enable a man to enter the services or to travel beyond the reach of surgical skill.

7. Children of the class of hospital patients, with ignorant parents.

Methods.—The following methods will be described :—

1. Bassini.
2. MacEwen.
3. Kocher.
4. Halstead.

(1) Bassini's Method

Stage 1. *Exposure and Separation of the Sac.*—An incision three to four inches long is made above Poupart's ligament; the inner end should not stray below the pubic spine. The incision should pass down to the external oblique aponeurosis, the external abdominal ring being exposed in the lower part. The superficial epigastric vessels will spurt, and need securing. The pillars of the ring are not evident, as they are prolonged on to the cord as the external spermatic fascia. A pair of dissecting forceps is pushed up through the external abdominal ring to act as a director, and then with a knife, between the two blades of the forceps, the aponeurosis of the external oblique is slit up for the whole length of the inguinal canal. The margins of the aponeurosis are secured with catch forceps. The cord is now exposed as far up as the lower margin of the internal oblique.

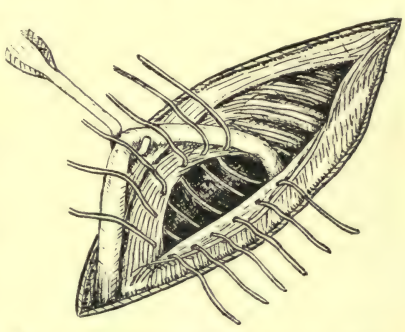


FIG. 139.—BASSINI'S RADICAL CURE OF INGUINAL HERNIA.

The cord is lifted from its bed and the sac of the hernia sought for. The structures of the cord are separated and spread out on the sac; the vas and the chief vessels lie posterior to the sac.

On spreading out the cord with two pairs of forceps the curved lower margin of a small acquired sac can usually be made out from its regular and white appearance. If it is a congenital hernia no lower border will be seen, as the sac is directly continuous with the tunica vaginalis; in this case the lateral margins must be sought. With the dissecting forceps the coverings of the cord are separated from the sac, which is cleared as far as the internal ring. Care must be taken in clearing the structures from off the sac that they are interfered with as little as possible, damage to the vas and the blood supply of the testicle being rigidly avoided.

Stage 2. Treatment of the Sac.—The sac is in every case to be opened, even when apparently empty. The interior is examined and a blunt instrument introduced and made to enter the internal abdominal ring so as to make sure that no portion of bowel or adherent tag of omentum is present. The sac is then twisted up so as to drive back anything which may possibly follow the instrument as it is withdrawn. The neck of the sac is transfixed with a curved needle and the ligature firmly tied, the free portion being cut short. In a congenital hernia the sac must be cut across above the testicle after being cleared at that point from the structures of the cord. The lower portion, which goes to form the tunica vaginalis, can be left open and no further notice taken of it. The upper end being treated in the same way as if it were the whole sac, its interior is explored, it is twisted up, ligatured, and cut short. Adhesions in the sac must be dealt with, omentum may be ligatured and cut away, bowel must be separated carefully if the adhesion be recent; if of long standing and firm the adherent portion of the sac must be cut round and the bowel and adherent portion returned together into the abdomen. Any pathological condition of the cord such as lipoma or varicocele may now be dealt with.

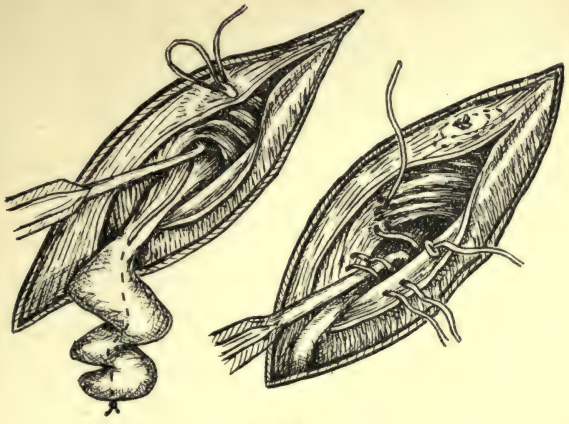
Stage 3. Treatment of the Canal.—The canal is strengthened by bringing the arched lower border of the conjoined tendon, transversalis, and internal oblique down to Poupart's ligament. This is done in the following way (Fig. 139). The cord is drawn up out of the way by means of a blunt hook held by an assistant. The surgeon passes sutures with a curved needle (silkworm gut, catgut, or kangaroo tendon) through Poupart's ligament, then behind the uplifted cord, and lastly from behind forwards through the lower margin of the internal oblique and conjoined tendon,

the finger guarding the fascia transversalis and the peritoneum from injury. Three to five such sutures are needed; when all are in place they are tied behind the cord and cut short. The cord is replaced and the aponeurosis of the external oblique sewn up in front with sutures which pass down low enough to close the external abdominal ring without unduly constricting the cord.

All bleeding points are dealt with so as to leave a perfectly dry wound. The skin incision is sewn up with silkworm gut.

(2) MacEwen's Method

Sir William MacEwen thinks that, however high up the sac may be tied, there always remains a dimple opposite the internal



A B

FIG. 140.—MACEWEN'S RADICAL CURE OF INGUINAL HERNIA.

A, Fixing the threaded sac to the anterior abdominal wall away from the internal (deep) abdominal ring. B, Inserting the sutures *in front* of the cord. (To make it clearer the external oblique has been divided.)

ring which is liable to become a pouch and again wedge open the inguinal canal. The sac is therefore puckered up and completely replaced in the abdominal cavity and fixed near the internal ring so as to act as a buffer to the inlet to the canal. The canal is then dealt with in a special manner so as to bring the conjoined tendon down behind Poupart's ligament.

Stage 1. *The Exposure and Clearing of the Sac.*—This is done in the same way as is described in Bassini's operation, with the exception that the external oblique is not divided; this renders the clearing of the sac a rather more difficult matter. It is very important that the sac should be freed right up to the internal

ring and the neck of the sac freed for half an inch round that opening.

Stage 2. Treatment of the Sac.—The free end of the sac is transfixed with an ordinary curved needle and a suture firmly tied. The needle is next made to transfix the sac several times as it approaches its neck, so that on drawing on the suture the sac will be puckered up. The needle is then removed, and the end of the suture is threaded on a special hernia needle. The hernia needle is now guided into the canal by the finger and made to transfix the muscular wall of the abdomen from within outwards about an inch above and to the outer side of the internal ring. The upper end of the wound is retracted to allow the end of the needle to appear. Considerable force must often be used to drive the blunt-pointed needle through the muscular walls. The suture is secured and the needle withdrawn unthreaded. The suture is then threaded on a sharp needle and fixed to the aponeurosis of the external oblique, after having been pulled tight so as to fix the puckered-up sac like a button above and to the outer side of the internal ring.

Stage 3. Treatment of the Canal.—The hernia needle threaded with strong catgut is passed from before backwards through the conjoined tendon, the forefinger protects the cord and the transversalis fascia, while the end of the hernia needle is made to pierce the tendon or the lower border of the internal oblique a little higher up from within outwards. This stitch is passed with a single sweep of the needle, which is then withdrawn, leaving a loop of catgut on the deep surface of the tendon. The two ends are threaded separately and each made to pass in front of the cord and pierce Poupart's ligament. Two or three such stitches are passed, and when all are in position they are tied and cut short. As the stitches are pulled tight the lower margin of the conjoined tendon is pulled down behind Poupart's ligament in front of the cord. The margins of the external oblique are made to overlap in the same way, a small aperture being left through which the cord emerges.

(3) Kocher's Method

In this method the sac is invaginated into the abdominal cavity and stitched to the parietal peritoneum above and to the outer side of the internal abdominal ring.

Stage 1. The Exposure and Separation of the Sac.—This is carried out in the same manner as in Bassini's method, except that the external oblique is not slit up. The neck of the sac is cleared as high as possible.

Stage 2. The Treatment of the Sac.—The sac being cleared, the free end is invaginated with a pair of dressing forceps, which are pushed right up through the internal abdominal ring and made to press against the anterior abdominal wall above and to the

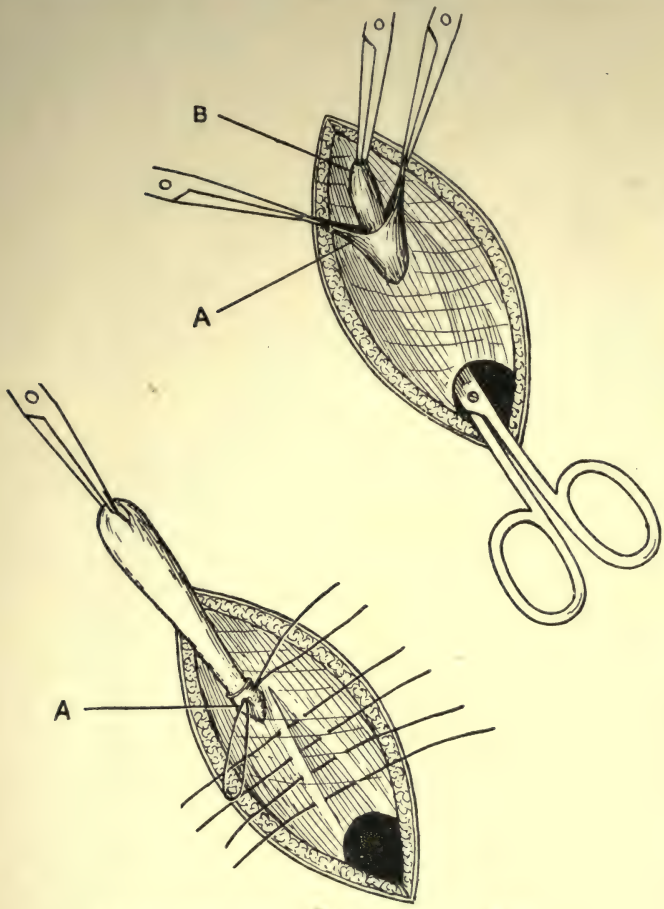


FIG. 141.—HERNIA: KOCHER'S OPERATION.

(*Wheeler's "Operative Surgery."*)

outer side of this opening. A small incision a quarter of an inch in length is made over the prominence thus produced, and the parietal peritoneum exposed and opened. The margins of the peritoneum are seized and the sac pushed through the opening and secured, the dressing forceps being withdrawn from the

inguinal canal. The sac is pulled forcibly out of the wound and crushed with forceps. A curved needle is then made to transfix the sac and the two margins of the peritoneum ; the ligature is tied and cut short, the stump disappearing through the muscles. The aponeurosis is then closed with the same needle and thread.

Stage 3. *Treatment of the Canal.*—With a curved needle deep sutures are passed through the apponeurosis of the external oblique, internal oblique, and transversalis above the cord, and then through Poupart's ligament below, so as to strengthen the anterior wall of the canal.

Formerly Kocher used to make a small hole in the external oblique above and to the outer side of the internal abdominal ring. Through this a long pair of dressing forceps were introduced and passed down the canal and out at the external ring. The forceps grasped the free end of the sac and were withdrawn, pulling the sac with them. The sac was then ligatured, sutured, and cut short, or sutured down to add strength to the anterior wall of the canal.

(4) Halstead's Method

Professor Halstead, instead of trying to repair the old canal and ring, makes the cord leave the abdomen through the internal and external oblique muscles and lie for the rest of its way subcutaneously, the inguinal canal being completely closed behind it.

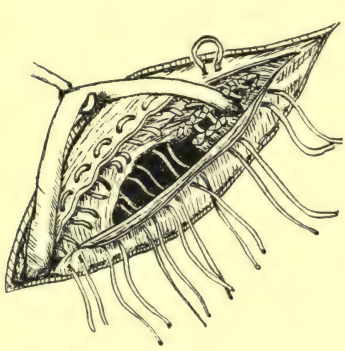


Fig. 142.—Halstead's Radical Cure of Hernia.

Stage 1. *The Exposure and Separation of the Sac.*—The incision extends from a point two inches above and to the outer side of the internal abdominal ring down to the spine of the pubis. The aponeurosis of the external oblique is slit up from the external ring to the upper extremity of the incision. The fascia transversalis and the internal oblique muscle are divided in the same way. The sac is now completely cleared.

Stage 2. *The Treatment of the Sac.*—With this free division of structures the neck of the sac disappears and becomes merely a continuation of the parietal peritoneum. The sac is carefully isolated and opened and its contents replaced, " The communication between the sac and the abdominal cavity is sometime s

large enough to admit one's hand." The peritoneum is sewn up with fine silk mattress sutures and the sac removed. The cord is then attended to; "all but one or two of the veins of the cord are excised," and the structure, reduced in size, is raised on a hook and held out of the way.

Stage 3. Treatment of the Canal.—Six to eight mattress sutures are now passed through the external oblique, internal oblique, and the transversalis muscles and transversalis fascia on the one hand, and the transversalis fascia and external oblique (Poupart's ligament) on the other. The two outer stitches pass through muscular tissues and the same structures on each side of the wound. It is these two outer stitches which are the important ones, for the cord leaves the abdomen between them. They therefore must not be close enough to constrict the cord, nor far enough apart to allow of a hernial protrusion between them. The cord at this point is surrounded with muscular tissue. All the sutures are tightened up and tied, totally obliterating the inguinal canal. The skin and subcutaneous tissues are sewn over the cord with a continuous suture.

Comment.—Of these operations the first two, those of Bassini and MacEwen, are the ones commonly performed in this country. Of the two the method of Bassini is the easier to perform, as the external oblique aponeurosis is slit up and a free view of the canal obtained; the sac is therefore easier to separate from the tissues of the cord. Bassini's method of narrowing the canal follows more closely nature's method of bringing the cord out of the abdominal cavity, and increases the valve-like action of the canal by suturing the conjoined tendon to Poupart's ligament behind the cord. On the other hand, MacEwen's method totally obliterates the internal abdominal ring by his sutures and by the pad formed by the folded sac, and brings the vas and accompanying structures almost straight out through the abdominal wall by suturing the conjoined tendon to the back of Poupart's ligament in front of the vas. The valve-like action of the canal is done away with, but on the other hand the vas is brought out between unyielding structures; below there is the ramus of the pubis, above the conjoined tendon, to the outer side the firm stitch binding the conjoined tendon behind the inner end of Poupart's ligament. The aponeurosis of the external oblique is not divided, as division is thought to weaken this structure.

Kocher's method is seldom performed in this country.

Halstead's method is needlessly severe for ordinary cases, while the results are no better than those of Bassini or MacEwen,

but after recurrences, the operation may be performed with advantage. Complications such as orchitis or atrophy of the testicle are liable to occur from interference with the blood supply of the organ if the veins are cut away as freely as recommended.

After treatment.—The wound is sealed with collodion and gauze, a dressing and pad applied and fixed in position with a spica bandage. The pad and bandage serves both to keep the part at rest and to prevent the accumulation of fluid under the edges of the wound. A pillow may be placed under the knee to relax the structures.

The patient remains in bed for three weeks, the stitches being removed about the tenth day. In an adult no hard work must be undertaken for two months from the date of the operation. Occasionally there is retention of urine for the first few days from stitch irritation. If the patient has afterwards to wear a truss the operation cannot be looked upon as a success.

OPERATIONS FOR FEMORAL HERNIA

Anatomy.—The femoral sheath is a funnel-shaped prolongation into the thigh formed by the fascia transversalis in front, and the fascia iliaca behind. The sheath is divided into three compartments, an outer for the femoral artery, an intermediate for the femoral vein, and an inner, the shortest of the three, the crural canal. The crural canal is about half an inch long, and is ordinarily filled with lymphatics and fat, continuous above with the extra-peritoneal fat. The canal is closed below and open above, the opening being known as the crural ring ; this is normally plugged with fat or with a lymphatic gland—the so-called septum crurale—and is of such a size as to admit the tip of the little finger, being larger in the female than the male.

The crural ring is bounded to the inner side by the sharp, free margin of Gimbernat's ligament, and the obliterated hypogastric artery, to the outer side by the compartment for the femoral vein and the deep epigastric artery, which separates the crural ring from the internal abdominal ring. Behind are the ramus of the pubis, the origin of the pectineus muscle and the fascia iliaca. In front are the fascia transversalis specially thickened to form the deep crural arch, the inner end of Poupart's ligament, which here receives the name of the superficial crural arch, and the small pubic branch of the deep epigastric artery.

The crural canal passes downwards behind the falciform ligament to end behind the upper part or the saphenous opening.

The possibility of the presence and the exact relations of an abnormal obturator must be remembered in connection with the crural ring.

Normally, the deep epigastric artery runs upwards and inwards in front and to the outer side of the crural ring, and gives off a small pubic branch, which runs inwards in front of the ring to the back of the pubis, where it anastomosis with the pubic branch of the obturator artery.

When the obturator artery is small, or has not developed, this anastomosis enlarges and constitutes the abnormal origin of the obturator.

The position of this abnormal vessel varies, but it is found on one or both sides in two out of every five subjects. In about 60 per cent. of cases in which it is present the vessel passes back-

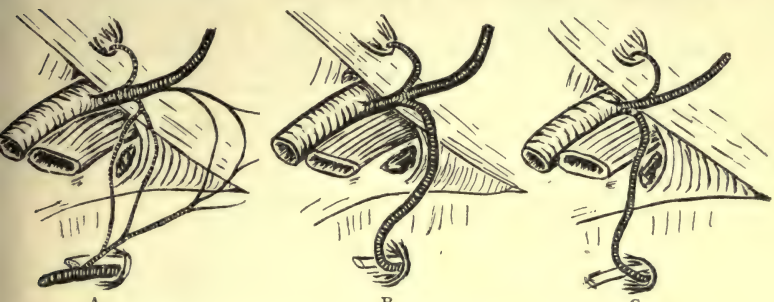


FIG. 143.—THE ABNORMAL OBTURATOR ARTERY.

A, Normal anastomosis between the pubic branches of the obturator and the deep epigastric arteries. B, Obturator artery replaced by enlargement of the branch of the deep epigastric—situated in the dangerous position. C, The same, but the artery in a safe position.

wards between the crural canal and the femoral vein, in 30 per cent. it passes backwards across the crural ring, and in the remaining 10 per cent. it passes inwards in front of the ring, and then arches downwards to its inner side, lying on Gimbernat's ligament. It is when the artery is in this last position that it runs a risk of being divided in operations for the relief of strangulated hernia.

"The chance of meeting with this abnormal obturator artery in the dangerous position to the inner side of the neck of the sac is only about one in forty" (Treves).

The direction of a hernial protrusion in this region must be attended to. At first the hernia descends vertically along the canal, next it passes forwards through the saphenous opening, and lastly, if it continues to enlarge, it does so in an upward and

outward direction towards the anterior superior iliac spine. The change of direction at the saphenous opening is supposed to be due to the anterior part of the hernia being pressed on and retarded by the crural arches, and the falciform edge of the saphenous opening sometimes known as Hey's ligament, the posterior part passing downwards and turning in consequence forwards, upwards, and outwards from under the edge of this ligament.

The coverings of hernia in this region are the structures it pushes before it.

1. Skin and fascia.
2. The cribriform fascia over the saphenous opening.
3. The anterior wall of the femoral sheath formed by the transversalis fascia.
4. The extra-peritoneal fatty tissue or septum crurale.
5. Parietal peritoneum or hernial sac.

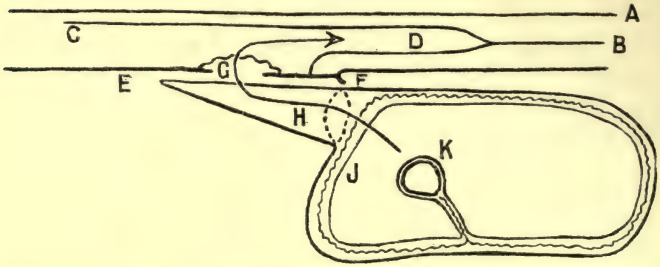


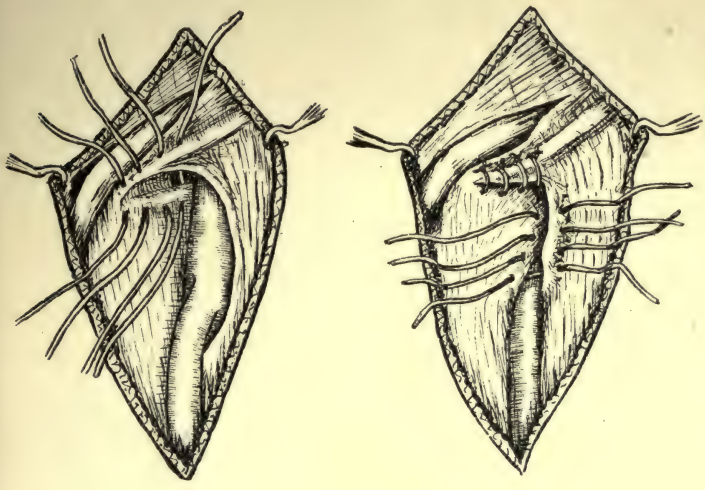
FIG. 144.—DIAGRAM OF FEMORAL HERNIA.

A, The skin. B, Deep fascia splitting into fascia of Camper C, and fascia of Colles D. E, Fascia lata of thigh attached to F, the inguinal ligament (Poupart). G, Saphenous opening covered with the cribriform fascia. H, Crural canal and ring. J, Peritoneum. K, Gut. The arrow denotes the formation of the hernia.

Position.—The patient lies in the dorsal position with the thigh slightly flexed and rotated outwards, the knee being supported on a sandbag. If the structures about the neck of the sac are to be relaxed, the limb should be rotated inwards slightly. The surgeon stands on the affected side with the assistant opposite him.

Operation.—*Stage* 1. *Exposure and Separation of the Sac.*—An incision is made starting from a point half an inch external to the pubic spine, and extending vertically downwards for about two inches. The sac is thoroughly freed as far up as the crural ring, care being taken not to injure the internal saphenous or the femoral veins. The neck of the sac is freed from its attachment to the abdominal wall for a little distance round the enlarged ring.

Stage 2. *Treatment of the Sac.*—The sac is opened and its contents replaced within the abdominal cavity. The sac is then twisted up, transfixed with a needle, and a ligature applied, and the portion distal to the ligature is cut off. By means of the same suture the stump may be fixed to the anterior abdominal wall, above Poupart's ligature, by passing the needle from within outwards through the conjoined tendon and the aponeurosis of the external oblique, and so drawing the stump upwards and stitching it in this position. Or the sac may be pulled through



A B

FIG. 145.—RADICAL CURE OF FEMORAL HERNIA.

A, Sutures to draw the inguinal ligament (Poupart) down to the periosteum of the pubis to close the ring. B, The femoral ring closed, sutures inserted to close the saphenous opening.

a small incision in Poupart's ligament and stitched in this position after the manner of Kocher.

Stage 3. *Treatment of the Canal.*—The most usual manner of closing this is by means of several sutures which are passed with a curved needle through Poupart's ligament, and then through the periosteum of the pubis in front of the ilio-pectineal line, the pectineus muscle and fascia over the muscle. When all are in position, they are tightened up and cut short. These stitches draw the inner end of Poupart's ligament down to the bone and pectineus muscle, and so close the crural ring.

The strong periosteum in front of the ramus of the pubis is sometimes known as Cooper's ligament.

The falciform ligament is then sutured to the pectineal fascia

so as to close the saphenous opening, leaving just sufficient room for the long saphenous vein. The skin incision is closed.

Sir Watson Cheyne prefers to make a curved incision over the region and turn a flap of skin inwards. The sac having been dealt with, a flap consisting of nearly the whole thickness of the pectineous muscle is dissected upwards. The convexity of the flap is transfixed twice with a strong suture, the two ends of which are threaded on a long-handled needle, carried up the crural canal, and made to pierce the abdominal wall above and to the outer side of the crural ring. On pulling on the ends the flap of muscle is drawn up the crural canal, and effectually plugs the opening; the stitch is then tied.

The operation is completed by stitching the falciform ligament down to the remains of the pectineus muscle and the periosteum behind.

OPERATION FOR THE RELIEF OF UMBILICAL HERNIA

Umbilical herniae fall into one of three clinical types.

1. Congenital Hernia of the Newly Born (*Exomphalos*)

This form is caused by an error in development. The coil of intestine which during one period of fœtal life is normally situated in the proximal end of the umbilical cord and withdrawn into the abdomen some months prior to birth, still remains contained in the proximal end of the cord. After birth, straining causes more intestine to be forced into the soft tissues of the cord, and unless an operation is promptly performed there is very little chance of saving the child's life. Often this form of hernia is found accompanied by other errors of development.

Operation.—The sac is isolated from the structures of the cord, opened, and the contents are returned to the abdominal cavity. The sac is twisted up, its neck ligatured and cut short; or the sac may be folded in the form of a pad and fixed to the anterior abdominal wall to one side of the umbilicus.

The edges of the ring are freshened and brought together as far as possible in layers. The umbilical vessels must not be interfered with. A pad must be fixed over the dressing with the bandage.

2. Infantile Hernia

This is the common variety met with in children, and is known to mothers as "starting of the navel." Its formation

is due to the stretching of the umbilical cicatrix from straining caused by digestive troubles, constipation, or phimosis. The condition seldom calls for operative interference, as there is a great tendency to natural cure. All that is needed is the application of a firm pad over the swelling and the removal of the cause of the straining. Should this treatment not prove sufficient, the radical cure can be performed.

3. Umbilical Hernia in Adults

This is usually met with in fat people, more commonly in women who have borne many children, and in whom the abdominal walls have become pendulous and atonic. These patients, from their flabby muscular system, obesity, and associated conditions such as bronchitis or heart trouble, are often very difficult to deal with. The hernia sometimes reaches enormous dimensions.

Operation.—The operation for radical cure is carried out on the lines of radical cure in other regions. The operation may be done through one incision, or two incisions may be made, one on either side of the neck of the sac, extending for some distance beyond the hernia; the length of the incisions will depend on the dimensions of the hernia. The incisions may be vertical or transverse, according to the fancy of the surgeon. The incisions are deepened and the neck of the sac cleared.

The sac is cautiously opened as the omentum and bowel are extensively adherent to its interior, and are usually irreducible.

The most tedious part of the operation consists in freeing the adhesions of the omentum and bowel from the interior of the sac.

When the contents of the sac are free they are returned to the interior of the abdomen. If the hernia is of large size, it is often very difficult to find room in the abdominal cavity to replace the large quantity of bowel which has for some time been accommodated in the sac of the hernia. Even after the removal of the omentum it is sometimes needful to excise several feet of the intestine before the remainder can be replaced.

When the contents of the sac have been returned the sac, together with the eliptical area of skin over it, should be removed. The opening in the abdominal wall is then closed. The parietal peritoneum is freed from the edges of the ring and closed with sutures. The cicatricial margins are then freshened; strong sutures are passed so as to bring the different layers to overlap one another in the same way as MacEwen brings the conjoined

tendon down behind Poupart's ligament in the radical cure of inguinal hernia. The skin wound is then closed.

No straining must be allowed for a considerable time after the operation. An abdominal belt to support the flabby walls of the abdomen should be worn for some months and only cautiously left off, as recurrence of this form of hernia is very common.

Until lately the result of these operations was extremely unsatisfactory, recurrence being rather the rule than the exception, but since the introduction of the use of silver wire filigrees or gridirons excellent results have been obtained, even in the worst forms of abdominal hernia. The method of inserting these flexible metal supports can be applied to any form of hernia which recurs, and is especially useful for the cure of protrusions which take place in the scar after draining septic conditions of the peritoneum.

The filigree should be well made and flexible in all directions; it need not be made with thick wire, and it should not have any ends protruding which might injure the bowel wall. It is inserted after the peritoneum and fascia transversalis have been sewn together, a bed being prepared between the fascia and the muscle. It need not be stitched in position, as the muscles are sewn together over the instrument and keep it in place. The wound is completely closed. Should sepsis ensue, the silver wire should not be removed, as the wound will granulate over it, and in all probability a good result will be obtained. The loops of wire become firmly fixed in fibrous tissue and prevent the scar from stretching.

OPERATION FOR THE RELIEF OF STRANGULATED HERNIA

This is one of the most important emergency operations of surgery, the surgeon being frequently called upon to perform it, and often in the most unfavourable conditions. The mortality of the operations is higher than one is led to suppose, twenty-five per cent. of deaths occurring after the operation (Thorburn). The mortality is highest in umbilical, lower in femoral, and lowest in inguinal hernia. The operation itself, however, is comparatively simple and free from danger, the mortality being chiefly caused by the delay in operative interference. In cases therefore where hernia is present and well-marked symptoms of strangulation have supervened, when systematic and thorough attempts at reduction by taxis have failed, the operation should be performed at once.

Contents of the hernia may be various, such as intestine, omentum, ovary, appendix, or bladder. The variety of the contents does not vary the procedure to any great extent, as the strangulation in all cases must be relieved.

Instruments.—In addition to the instruments needed for abdominal operations, a hernia director and a hernia knife should be provided. The hernia knife should be a long-hafted curved knife with a short cutting edge, the point of the knife being bevelled and blunt to allow its being insinuated under the constriction. If a special knife is not at hand, a curved blunt-pointed bistoury should be selected with the cutting edge reaching to the end, which should be without the thick rounded extremity seen on some knives, which renders them quite unsuitable for introduction in the case of a very tight constricting ring.

Preliminaries.—If the vomiting is fæcal and frequent it is a good plan to wash out the stomach with warm water to which has been added a little potassium permanganate. This will allay the vomiting and not only alleviate the condition of the patient, but also minimize the risk of the intestinal contents being sucked into the air passages when under the anæsthetic.

Operation.—The general principles of operating for the relief of strangulated hernia are here considered, the details suitable to each particular form will be considered later.

Stage 1.—The exposure and opening of the sac. An incision is made in the long axis of the tumour and situated so as to pass over the constricting neck. The incision is deepened by dividing the tissues for the whole length of the original wound until the sac is exposed. The various anatomical layers demonstrated in the dissecting-room can never be displayed in the same way during the operation, and any persistent attempt at their recognition will tend rather to confuse than help the operator. The tissues are often congested and œdematous either from the condition of the hernia or from too violent and prolonged attempts at taxis. The recognition of the sac is often helped by seeing the purple colour of the congested contents through the wall, or seeing the presence of fluid and perhaps gas in the interior. Picking up and estimating the thickness of the tissue is a great help. The shining appearance of the lining membrane of the sac will tell at once when the sac is opened unless this appearance has been lost, as in cases where local peritonitis has been set up. The escape of fluid when the sac is opened is perhaps the most constant guide, although even this may be absent or nullified by the amount of fluid which escapes from the œdematous tissues

outside the sac. If "the arborescent appearance of the vessels on its surface" be relied on for the recognition of the sac, there is danger of opening the gut by mistaking the vessels of the latter for the appearance described for the former. If doubt exist the structure should be pulled down and its relations to the parts at the neck ascertained, whether it is continuous with the structures on either side or passes through the neck into the abdomen. A portion of the sac should be pinched up free from the subjacent contents and opened with the knife held on the flat.

Stage 2. *Division of the Stricture.*—The contents being fully exposed, are examined and their treatment determined upon. They should be carefully washed with saline to remove any fluid which may contain septic organisms which have passed through the damaged gut wall. If they are in a fit condition to be returned to the abdomen, attention is at once paid to the neck of the sac. The finger is passed up to the constricted area and the cause of the constriction being made out, the best method of dividing it is determined upon. If the tightness of the constriction permit, the point of the fore or little finger should be used as a director, the tip being placed under the edge of the constriction. The hernia knife is then passed on the flat along the pulp of the finger and its blunt point introduced under the constricting edge. If a curved bistoury be used it should be passed along the finger in like manner. In many cases the neck of the sac is too tight to allow of the finger being used, and a flat director must be substituted broad enough to prevent the bowel overlapping the edges and being wounded by the knife. The director is held in the left hand while the knife is passed as before through the neck of the sac, care being taken to protect the bowel from injury. When the knife is in position the edge is turned towards the constricting band and made to divide it. It is better to make two or three small cuts in the neck rather than a single large one, as by this method neighbouring structures run less chance of injury. The direction in which the division must be made is important, in the inguinal and femoral varieties the only safe direction is upwards and inwards.

Sometimes the constriction may be relieved by passing a pair of artery forceps through, and then forcibly opening them to stretch the aperture.

Stage 3. *Treatment of the Contents.*—The constriction having been relieved the knuckle of bowel *is pulled down* and a careful examination made as to its condition. The sites at which greatest injury to the knuckle of bowel takes place are, in their

order of severity, (1) on each side of the constricted portion of the entrant limb; (2) on each side of the constricted portion of the exit limb; (3) midway between the two on the side of the bowel opposite the mesenteric attachment. These three portions should be carefully examined and if the bowel is fit to replace, it should be wiped dry and, in the case of inguinal and femoral hernia, after slightly flexing the thigh to relax the structures round the ring, coaxed through the divided neck into the abdomen. An instrument should always be introduced after the coil of intestine to make sure that it has been replaced within the cavity of the abdomen, and that no other constriction is present.

Stage 4. *Treatment of the Sac.*—In all cases in which the general

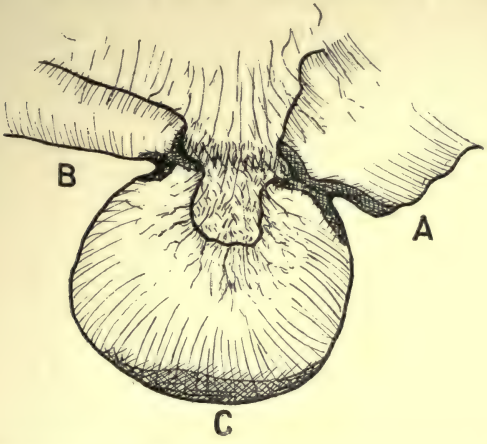


FIG. 146.—STRANGULATED KNUCKLE OF GUT, SHOWING AREAS WHERE SLOUGHING IS MOST LIKELY TO TAKE PLACE.

A, At the ring on the entrant side. B, At the ring on the exit side. C, At the anti-mesenteric border.

condition of the patient permits the sac and canal should be dealt with as in a radical operation. If the patient is not in a position to stand any such procedure the sac may be obliterated with a few sutures and left *in situ*, the skin wound being closed. If recurrence takes place later a radical operation can be performed in favourable circumstances. In all cases the simpler the procedure adopted the better for the patient, for the great object of the operation has been attained with the relief of the obstruction.

Complications.—Having now described a favourable case we turn to the consideration of the more important complications.

1. *Presence of Omentum.*—If the omentum found in the sac

is small in amount, healthy, and free from adhesions either to the sac wall or the gut, it may be replaced in the abdomen. If as usually happens it is matted into a thick mass, is adherent either to the intestine or the sac wall, or is present in large amount, it should be removed. On drawing down the matted portion a thin neck will be found, this is transfixed and ligatured. It should be ligatured in sections if the mass is large, so as to avoid the possibility of wounding a loop of bowel round which the intestine might be matted. The adhesions must be carefully dealt with, the omentum being ligatured and cut short, only very gentle attempts at separation of the omentum from the intestine should be made if the latter is at all softened by the strangulation. It is sufficient in such cases to trim off the adhesion with scissors. All adhesions round the neck of the sac should be freed, as they tend to cause recurrence of the hernia.

2. *Adhesions to the Sac.*—In the case of the omentum these have already been dealt with; it only remains to discuss the adhesions of the gut to the sac wall. If the adhesions are recent it may be possible to separate them without damage to the gut, but this will rarely be found a safe method as the gut wall often tears more readily than the adhesion. It is better to cut round the adhesions and to free the gut with a portion of the sac wall still adhering to it. The size of the portion attached may be reduced with scissors before replacing it in the abdominal cavity.

3. *Gangrene of the Intestine.*—In cases where the bowel is black, green, dark, with grey or white patches, black with loss of lustre and the feel of wet blotting paper—its resilience having quite disappeared—there can be no doubt as to the death of the intestine. It is in cases where the condition of the bowel just stops short of these that there is difficulty in deciding whether the gut is in a fit state to be replaced. Roughly the intestine may be returned if it is any colour except a dead lustreless black, if it is resilient to the feel and the peritoneal coat has not lost its shiny appearance. When in doubt it is a wise thing to return it, as injured gut never travels far from the position just internal to the ring in which it is placed. If the replaced gut subsequently dies, adhesions form, and the leak takes place at the site of operation, the wound having been drained and not stitched up.

If the bowel is dead three courses are open.

1. Simple incision of the gangrenous bowel.
2. Resection with the formation of an artificial anus.
3. Resection with anastomosis.

1. *Simple Incision.*—This should only be undertaken when the bowel has leaked, and the contents of the sac have become

septic. The constriction round the neck of the sac should not be divided, as the obstruction ceases when the swelling goes down after the bowel is incised and laid freely open. The adhesions serve to shut off the general peritoneal cavity. The artificial anus is dealt with later.

2. *Resection with the Formation of an Artificial Anus.*—After washing clean the interior of the sac, the stricture is divided and the injured loop of bowel pulled down until healthy bowel appears on each side; the two portions are fixed to the wound and the knuckle opened.

3. *Resection with Anastomosis.*—This can be done in few cases, as the condition of a patient in whom strangulation has progressed so far is hardly likely to be such as to recommend a prolonged operation. If it is thought advisable to perform anastomosis, an end-to-end anastomosis should be performed; artificial aids such as buttons and bobbins are not easily returned through the divided ring.

4. *Wound of Intestine.*—This may be due to carelessness on the part of the operator in opening the sac, or to the bowel curling over the edge of the director when the stricture is being divided. The latter is the most common accident, and is the worse, as fæces and flatus escaping from the depth of the wound may be the first intimation that the accident has occurred. This is another reason, if one were needed, for pulling down the two ends of the loop of bowel after division of the constriction. The wounded bowel must be packed off at once and the edges of the cut inverted with Lembert sutures. If the bowel is distended, advantage may be taken of the opening to pass a rubber tube in and evacuate the bowel contents before closing and returning the gut to the abdomen.

Having discussed the treatment of strangulated hernia in general, it only remains to say a few words applicable to the individual varieties.

Strangulated Inguinal Hernia

An incision three inches in length should be made in the long axis of the tumour, the centre corresponding to the neck of the swelling; only rarely need it encroach on the scrotal tissues. The tissues are divided down to the sac.

The constriction in direct hernia is at the external abdominal ring; in indirect hernia it may be situated at either ring, or more rarely, in young subjects, muscular spasm may cause the constriction in the canal. Any tight tissue found around the neck of the sac is divided and the constricting band made out. The

knife is passed with the precautions already laid down and the band divided in an upward and slightly inward direction parallel to the course of the deep epigastric vessels.

It is in this variety of hernia that secondary interstitial sacs are most likely to be met with, and it is therefore specially advisable to make sure that the bowel has been returned into the abdominal cavity, and not into an interstitial part of the sac.

If the contents of the sac are in a satisfactory condition, and the general state of the patient permit, some form of radical cure should always be attempted to obviate the necessity of a subsequent operation.

Strangulated Femoral Hernia

A vertical incision about three inches long is made over the inner part of the tumour, its centre corresponding to the saphenous opening. The structures are divided cleanly down to the sac. The stricture is situated at the entrance to the femoral canal by the sharp free margin of Gimbernat's ligament. It is this ligament which the surgeon tries to feel with his finger. It is well to divide this structure by nicking the ligament in two or three places rather than by one large cut. The direction in which the cuts in the constriction are made should always be inwards and slightly upwards. The femoral vein lies to the outer side, the bone behind, and there is a danger of wounding the spermatic cord or deep epigastric artery in front.

The only serious complication especially associated with this form of hernia is wounding an abnormally placed obturator artery. One of the abnormal positions of this artery is running down on Gimbernat's ligament at the inner margin of the femoral canal (see p. 335). In this position it is liable to injury. The danger is minimized by following the above-mentioned plan of only nicking the ligament instead of gashing it deeply. If the artery is wounded, there is an escape of blood from the depths of the wound. If this happens the incision must be enlarged and an attempt made to secure the vessel as it passes inwards in front of the canal. If the artery cannot be secured, firm plugging must be relied on, or an incision made above Poupart's ligament and the deep epigastric artery secured.

Strangulated Obturator Hernia

In addition to the ordinary symptoms of strangulated hernia, there may in this variety be two others—pain on abduction of the thigh due to the increased pressure of the adductor muscles

on the sac, and pain along the course of the obturator nerve from pressure on the nerve in the obturator canal. The sac is situated beneath the pectineus muscle to the inner side of the capsule of the hip, and between the adductor longus tendon on the inner side and the femoral vessels on the outer side. The sac protrudes either in front of or through the upper part of the obturator externus muscle, and the relation of the vessels and nerves to the neck of the sac is a variable one. This form of hernia is more frequently met with in females than males, and in the former some information may be obtained from a vaginal examination.

A vertical incision three to four inches long is made, starting from a point mid-way between the femoral artery and the pubic spine. The incision is carried down to the anterior surface of the pectineus, the deep external pubic vessels being divided, care being taken to avoid injuring the long saphenous and the femoral veins. The tendon of the adductor longus is exposed. The sac is either reached by dividing the pectineus across or by splitting the muscle in the direction of its fibres. The sac is now exposed, and the relation of the vessels and nerve to the sac is, if possible, made out. When the sac has been opened the neck is divided away from the vessels. If the position of the vessels cannot be made out, the constriction should be relieved by cutting backwards, as the vessels are less likely to be behind than on one or other side of the sac. When the contents have been reduced the sac should be ligatured and cut short.

The condition may only be recognized when the abdomen has been opened to ascertain the cause of the obstruction, and an attempt may be made then to relieve the obstruction from the abdominal cavity.

CHAPTER IX

Operations on the Genito-Urinary Tract

Kidney—Bladder—Urethra—Penis and Scrotum—Testicle—Ovaries—Uterus

OPERATIONS ON THE GENITO-URINARY SYSTEM

THE KIDNEY

Anatomy.—The kidneys lie much higher up than the student is apt to suppose. The left kidney lies entirely in the hypochondrium, while the right lies slightly lower and just encroaches on the umbilical zone. Two-thirds of each organ lie internal to vertical mid Poupart lines, the upper poles being nearer the middle line than the lower.

Posteriorly the kidneys may be marked out by four lines. Two transverse and parallel lines drawn outwards, one from the lower edge of the eleventh dorsal spine, and the other from the lower edge of the third lumbar spine. Two vertical and parallel lines, the one drawn at a distance of one and a half inches, and the other at three and three-quarter inches from the mid line. In the oblong space thus marked out the kidney lies (Morris). The upper poles of the kidneys lie opposite the tenth interspace, and the eleventh and twelfth ribs shield their upper portions posteriorly. The anterior relations of the organs differ on the two sides. In front of the right kidney are from above downwards, the liver, the hepatic flexure of the colon, and the small intestine, while the second part of the duodenum lies in front of the hilum. In front of the left kidney are, from above downwards, the stomach, the splenic vessels and pancreas and the small intestine, while the outer border is overlapped in the upper half by the spleen, and in the lower half by the colon. Posteriorly, the relations on both sides are as follows: the diaphragm, and if a deficiency in this muscle exists above the external arcuate ligament, the kidney

may come into contact with the pleura ; the anterior lamella of the posterior aponeurosis of the fascia transversalis which separates it from the quadratus lumborum muscle ; the psoas, against the outer side of which the organ rests ; the fascial lining of the abdomen, diaphragmatic, and transversalis. Separated by the structures already mentioned are the eleventh and twelfth ribs, and the sub-costal, ilio-hypogastric and ilio-inguinal nerves, and the sub-costal and first lumbar arteries, all of which cross

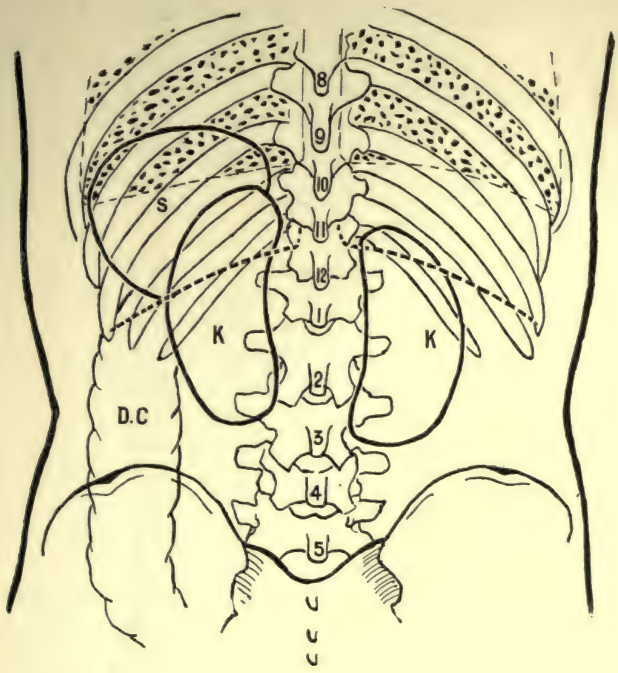


FIG. 147.—SURFACE MARKING OF THE VISCERA FROM THE BACK.

S, Spleen. K, Kidney. D.C, Descending colon. Interrupted line marks the lower margin of the pleura. Lower margin of the lungs is shown.

obliquely downwards and outwards. The pleura may sink below the level of the inner end of the twelfth rib, and so be injured during an operation.

The inner margin of the right kidney approaches very near and may touch the inferior vena cava ; the left kidney is at least an inch from the aorta.

In the hilus of each kidney lie from before backwards the artery, vein, and the pelvis of the ureter. Abnormal renal

vessels may be supplied to various parts of the kidney, most usually to the front of the lower pole. Certain abnormalities must also be mentioned; one kidney may be absent, the lower poles of the two kidneys may be fused together in front of the aorta, forming a horseshoe kidney, while one or both kidneys may be situated very much lower down than normal, even in front of the sacrum. Occasionally a double ureter is present.

Methods of Exposing the Kidney

1. The Lumbar Route.—This is an extra-peritoneal method of exposing the kidney, and is the one most commonly used. It is to be followed in all septic cases, or in explorations where sepsis is likely to be met. By it the kidney is easily found, and may be explored or removed, while if the ureter be found at fault it can be followed downwards behind the peritoneum by prolonging the lower end of the incision.

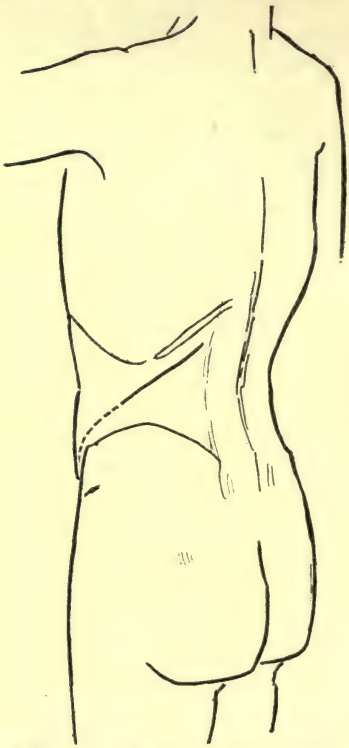


FIG. 148.—KIDNEY APPROACHED BY THE LUMBAR ROUTE.

Dotted line shows prolongation necessary to follow the ureter.

Its disadvantages are that in large tumours the space between the crest of the ilium and the last rib does not allow free room for manipulations. It does not allow palpation of the opposite kidney. In fat people the kidney may be at great depth of tissue, while in some cases, especially on the left side, the kidney may lie higher up than usual and be completely under cover of the ribs.

The usual lumbar incision starts from the angle formed by the outer border of the erector spinæ and the last rib, and runs downwards and outwards, so that if it has to be prolonged it just misses the crest of the ilium by about half an inch. This is the incision commonly used, and is very preferable to the next, which consists of two parts—a vertical incision which runs from

rib to the iliac crest along the outer border of the erector spinæ muscle, and a transverse incision made outwards from the centre of the vertical cut.

2. The Abdominal Route is much less commonly used than the lumbar, as it entails opening the peritoneal cavity. It has the advantage that it allows the condition of the kidney on the opposite side to be ascertained by direct palpation, and in a large tumour such as a sarcoma plenty of room is available. But in all cases where pus is present this route entails greater risks than the lumbar route. The exposure is usually made through the linea semilunaris.

Nephro-Lithotomy

Position.—The patient lies well over on the sound side, with the knees and hips bent to prevent him rolling in either direction. A large sandbag is placed under the patient's waist so as to open out the costo-iliac space.

The surgeon stands behind the patient's back, one assistant opposite and another by the side of the surgeon.

Operation.—*Step* 1. *Exposure of the Kidney.*—An incision four inches long is made from below the twelfth rib close to the outer border of the erector spinæ muscle, obliquely outwards and downwards across the costo-iliac space. The incision is deepened through the superficial structures, and the fibres of the latissimus dorsi and external oblique muscles are exposed, running in a vertical direction. Both muscles are divided throughout the incision, laying bare the internal oblique, whose fibres run upwards and inwards.

The internal oblique is similarly dealt with. As soon as the internal oblique is divided the glistening posterior aponeurosis of the transversalis comes into view. If the sub-costal nerve and vessels are seen they are drawn to one side. The aponeurosis is next divided, and the peri-renal fat usually bulges into the wound. The edges of the wound are held apart with broad retractors, and as the peri-renal fat is separated the kidney comes into view. The assistant makes strong pressure on the front of the abdomen to bring the kidney nearer the surface.

Step 2. *Locating the Stone.*—The kidney is then palpated in a systematic manner. The position of the shadow in the diagram should be recalled, and that part of the organ palpated first, otherwise the fingers are passed in front of the kidney to the hilus. The pelvis, the anterior surface, the posterior border, and the posterior surface are all carefully felt to try and detect the presence of a hard area. If this fails long needles may be

used to explore the interior of the organ by stabbing towards the pelvis.

Step 3. *Removal of the Stone.*—Before attempts are made to remove the stone, gauze should be packed into the depths of the wound to limit the flow of septic urine. On account of the fear of causing a urinary fistula, incisions into the kidney used to be placed as far as possible from the pelvis of the kidney. All incisions therefore passed from the outer border through the whole thickness of the kidney tissue to reach the pelvis and remove the stone.

Considerable hæmorrhage results from this procedure, and the destruction of a wide area of the secreting substance of the

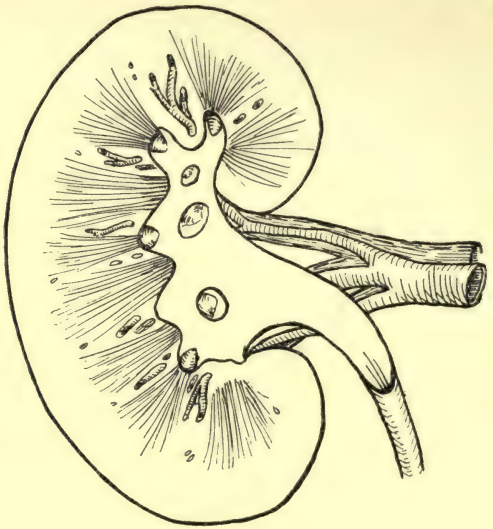


FIG. 149.—DIAGRAMMATIC SECTION OF A KIDNEY.

kidney must take place before a large stone can be removed. It is difficult moreover to be certain through the whole thickness of the organ that a small part of the calculus has not been left behind to act as a nucleus for a future stone.

This route therefore is to be condemned as inflicting unnecessary injury on the tissues. If it is ever thought advisable to incise the thickness of the organ, this should be done at a point rather behind the outer border of the organ, and a blunt instrument should thrust toward the pelvis parallel to the posterior surface of the kidney. This follows " the bloodless line " (Max Brödel).

The best method, however, of removing a stone lying in the pelvis of the kidney is to make a transverse incision directly over the stone on its posterior aspect. The major part of the incision is into the upper part of the ureter and the pelvis, but if more room is needed it may be prolonged outwards into the substance of the kidney. Much less damage is done by this incision, and it is found that, whether the wound is sutured or not, the leakage is only temporary.

As soon as one stone is removed further exploration should always be carried out to determine the presence of others; the

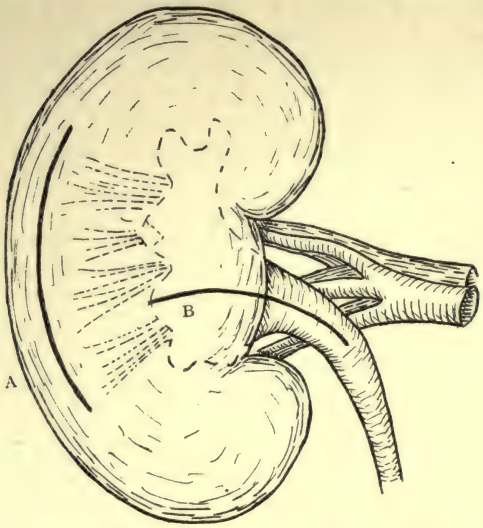


FIG. 150.—INCISIONS INTO THE KIDNEY.

Showing (A) incision along the least vascular area, note the number of pyramids destroyed. B, An incision prolonged backwards from the pelvis will only pass through one pyramid and gives better access.

presence of facets on the stone removed is an indication that others have been present. If more than one stone is present they can all be removed through the original wound. Before relinquishing the attempts to ascertain if more stones are present, a long flexible probe should always be passed down the ureter to the bladder to make sure that the manipulations have not forced a stone into the tube.

Step 4. *Closing the Wound.*—The wound in the kidney or pelvis is brought together by catgut sutures. The gauze packing is removed and the wound flushed out. The different layers of the abdominal wall are brought together by catgut sutures,

sufficient room being left to allow a drainage tube to pass from the kidney wound to the surface of the skin, so that any leakage of septic material has a free outlet. The remainder of the skin incision can be closed.

Nephrectomy

The removal of a kidney is performed for tumour of the organ, or disorganization from trauma, tubercle or calculus, and in some cases for the cure of a urinary fistula.

In all nephrectomy operations the first step is to ascertain the presence and condition of the organ on the opposite side. *No one is justified in removing one kidney unless he has previously assured himself that the other is capable of maintaining the life of the patient.* It is no part of this book to enter into surgical diagnosis, but the following points will remind the student of the methods by which the condition of the other kidney is examined.

1. The history of the illness.
2. Palpation of the abdomen.
3. Examination of the lower ends of the ureter and the flow of urine from each, by means of the cystoscope, in conjunction with which the injection of colouring matter into the circulation is most useful.
4. The examination of the urine from each organ collected by means of Luy's separator or by catheterization of each ureter.
5. X-rays may give useful information as to diseased conditions.
6. Actual palpation through an incision in the peritoneum.

Nephrectomy may be performed—

1. By the lumbar route, which is extra-peritoneal.
2. By the abdominal route, which is trans-peritoneal.

1. *Lumbar Nephrectomy*

Position.—As in the last operation.

Operation.—*Step* 1. *Exposure and Freeing of the Kidney.*—The kidney is exposed through the same incision and in the same manner as described in dealing with nephro-lithotomy. As soon as the kidney has been examined and the necessity for removal been determined, the incision may have to be enlarged by prolongation of the lower end forwards so as to get more room. The parts are well retracted, and the assistant pressing on the anterior abdominal wall brings the kidney into the wound.

The soft peri-renal fat is then stripped from the organ by the finger; this may take a considerable time in cases where there has been peri-renal inflammation or abscess formation, as the tissues become tightly adherent to the organ. Care must be exercised especially, in dealing with the lower pole, as an abnormally placed renal artery may easily be mistaken for a fibrous band.

Step 2. Securing the Pedicle and removing the Kidney.—When the kidney has been freed and the pedicle can be seen, the ureter should be secured and divided between forceps a little way below the pedicle.

The pedicle should not be drawn on roughly as the vein has been known to tear from the vena cava with fatal results, this is more likely to occur on the right side, where the vein is shorter.

The vessels of the pedicle are isolated by insinuating between them a curved aneurism needle already threaded. The pedicle is relaxed as each ligature is tied. The ends of the ligature are left long. The pedicle is then grasped by a pair of artery forceps, just distal to the ligatures, and is cut through on the distal side of the forceps, and the kidney removed. The end of the pedicle is steadied by the uncut ligatures, and the forceps cautiously removed so that any vessel which has escaped ligature may be secured. The ligatures are then cut short. The lower part of the ureter is ligatured after being crushed with forceps.

Step 3. Closing the Wound.—This is done with buried catgut sutures uniting the layers of muscle together. If sepsis is feared a drain should be placed to drain the kidney bed.

2. *Abdominal Nephrectomy.*

Operation.—*Step 1. Opening the Abdomen and Examining both Kidneys.*—With the patient lying on the back an incision is made in the linea semilunaris from the costal margin downwards for four or five inches.

The peritoneum is opened in the usual way and the hand passed into the cavity. The kidney on the opposite side is carefully examined. If everything is found satisfactory the nephrectomy is proceeded with, and the relations of the diseased kidney made out.

Step 2. Exposure and Separation of the Kidney.—The small intestines are pushed to the opposite side and the body kept slightly rolled over by placing a sandbag under the loin. This allows the intestines to fall away from the wound. The colon

is then made out and the peritoneum divided to its outer side for a distance of four to five inches. The peritoneum is freed from the posterior abdominal wall, and drawn up to the wound in the anterior abdominal wall and fixed there with artery forceps. By this means the general peritoneal cavity can be shut off effectually, the operation after this being conducted extra-peritoneally. If the condition is not a septic one there is no need to shut off the peritoneal cavity in this manner, and it is sufficient to thrust the peritoneum and colon inwards over the kidney or the general cavity may be packed off with gauze. The kidney is then exposed by tearing through the extra-peritoneal and peri-renal fat. The organ is separated from adhesions, care being taken always to keep close to the capsule.

Step 3. *Securing the Pedicle and Removing the Kidney.*—When the kidney has been freed sufficiently the pedicle is examined. The ureter is first secured and divided between forceps and then the pedicle secured by two or three ligatures passed by means of a curved aneurism needle; the ends of the ligatures are left long. The arteries should be secured before the veins. The pedicle is grasped by artery forceps between the ligature and the kidney and divided on the distal side of the forceps. The kidney is removed. The pedicle is released from the forceps, and if all bleeding is controlled the ligatures may be cut.

The ureter is then dealt with. If healthy it is crushed, ligatured, and dropped back; if it is thickened and diseased, as much of the tube should be removed as can be conveniently reached through the wound.

Step 4. *Closure of the Wound.*—The space occupied by the kidney is swabbed dry, and if septic material has escaped a counter opening should be made in the loin by thrusting a pair of forceps backwards and cutting on their points. The peritoneum on the posterior abdominal wall should be sutured to shut out the septic material from the general peritoneal cavity.

The anterior abdominal wound can then be closed in the usual way.

Nephropexy.

It is necessary to fix the kidney to the posterior wall in cases where it is floating or wandering to such an extent as to cause kinking of the ureter and distension of the pelvis of the kidney. The operation is most successful in cases where there is actual organic change commencing in the kidney or where the pain cannot be controlled by any other means, and is producing

a condition of marked neurasthenia. In this operation the kidney is always approached through the loin.

Operation.—*Step* 1. *Exposure of the Kidney.*—The kidney is exposed in the same way as already described. If the organ is very mobile some difficulty may be experienced in guiding it into the wound. When once the kidney has been induced to enter the wound the assistant should keep it in position by pressing steadily on the anterior abdominal wall with his closed fist.

Step 2. *Method of Securing the Kidney.*—The kidney is fixed to the lumbar muscles by firmly stitching it in position in the following way. With the kidney fully exposed in the wound, a crucial incision is made with the knife so as to divide the capsule of the organ without damaging the cortex. One incision passes along the curvature of the kidney from pole to pole; the other incision is at right angles to this.

The four flaps thus marked out are stripped back from the cortex and secured by artery forceps; this leaves a raw area of kidney exposed, from which a slight amount of oozing occurs. These flaps of kidney capsule are stitched to the lumbar muscles by catgut sutures mounted on curved needles. The needle is entered deeply through the lumbar muscles, then takes a firm grip in and out of one of the two upper flaps of the capsule, and then returns through the lumbar muscles to emerge close beside its point of entry. Two or more such sutures are entered through each of the two upper flaps; when all are in position they are tied and cut short, and the kidney is thus drawn firmly to the upper angle of the wound. The two lower flaps are then similarly dealt with.

Step 3. *Closure of the Wound.*—This is done by bringing together the layers of divided muscles with buried catgut sutures, so that the muscles cover in the raw area of the kidney. No drain is needed.

Comment.—This method of fixing the kidney is entirely satisfactory, and the capsule is secured permanently to the muscles and holds the kidney in position while the raw surface itself becomes adherent to the deep surface of the muscles. No damage is inflicted on the organ.

The older method of passing sutures deeply through the substance of the cortex and so fixing the organ to the muscles has proved unreliable, and should be condemned.

Rest in bed should be insisted upon for three weeks, and no violent exercise should be permitted for at least two months.

THE BLADDER

Supra Pubic Cystotomy

The bladder is opened above the pubis either for drainage or to remove stones, growths, or an enlarged prostate. The operation is performed outside the peritoneal cavity with the bladder distended so that the organ comes to lie in relation to the lower part of the anterior abdominal wall. The distended bladder lifts up the reflection of the peritoneum so that there is little danger of wounding this membrane.

Operation.—A catheter is passed into the bladder and the organ distended with saline until a rounded tumour can be felt well above the pubis ; distension to the level of the umbilicus is not necessary. An incision is made two to three inches long in the middle line immediately above the pubis. The sheath of the rectus is opened, and the two muscles are separated with retractors. At this level there is no sheath behind the rectus muscle. The incision is deepened through the loose extra-peritoneal fatty tissue which separates the bladder from the anterior abdominal wall, until the bladder is exposed at the bottom of the wound. The bladder is grasped with artery forceps and steadied; it is stabbed with the knife. A gush of saline follows on the withdrawal of the knife. The forefinger of the right hand is plunged into the hole in the bladder wall, and prevents the further escape of fluid or regulates it until the interior of the bladder can be satisfactorily explored. If the bladder is too distended the finger cannot reach to the deeper parts. Exploration is helped by passing the forefinger of the gloved left hand into the rectum, when the base of the bladder and the prostate may be manipulated between the two fingers. This, however, is not always necessary, and removal of stones can be effected without it. A suitable pair of forceps is passed down into the bladder and guided by the finger until the stone is caught and removed.

The wound in the bladder wall may be sewn up and the edges inverted with fine catgut sutures, and the abdominal wound partially closed, a tube being inserted to drain the pre-vesical space. If this is done a catheter should be passed into the bladder and tied in position to prevent any distension taking place which would put a strain on the sutures in the bladder wall.

If it is decided to drain the bladder through the supra pubic

wound, one or two catgut sutures are passed through the wall of the bladder and through the tissues of the abdominal wall on each side so as to sling the opening in the bladder up to the abdominal wound. The opening, if left alone, will gradually close of itself in the course of three to five weeks.

Removal of the Prostate

Operation.—1. *Supra-Pubic Cystotomy.*—A catheter is inserted and the bladder is distended and a supra-pubic opening made into the viscus in the way already described, and the right forefinger inserted, and the condition of the prostate ascertained.

2. *The Enucleation of the Prostate.*—The forefinger of the left hand, which is encased in a rubber glove, is then inserted into the rectum, and lifts up and steadies the prostate.

With the right forefinger the mucous membrane of the bladder is torn through at the side of the catheter, which projects from the internal urinary meatus. The finger then comes in contact with the capsule of the prostate, outside which it works steadily so as to release the organ from the mucous membrane over it. When this is done the finger passes downwards between the capsule of the prostate and the sheath of the prostate, the latter being formed by the tough recto-vesical fascia in the layers of which lies the prostatic plexus of veins. The finger works steadily downwards to the apex of the gland, using no undue force and without inflicting damage on the fascial sheath, so that no great hæmorrhage should be met with. When the apex of the gland is reached the catheter is withdrawn and the mucous membrane of the prostatic urethra is again torn through, and the gland is free in the bladder cavity.

3. *Removal of the Gland.*—The prostate is then grasped by suitable forceps and removed through the supra-pubic wound, which may have to be enlarged before the tumour can be released. A tube is then passed into the bladder, which is flushed out with hot saline solution to stay any hæmorrhage and to remove clots.

The wound in the bladder is sewn to the abdominal wound, which is then partially closed, a wide tube being left in to drain off the urine and through which the bladder may be irrigated from time to time. No instruments need be passed through the urethra until the patient begins to pass his water himself. The supra-pubic wound needs frequent dressing with a plentiful supply of absorbent material to soak up the urine. The wound gradually closes and the patient regains control of the sphincter.

Comment.—In this operation the whole prostate is removed together with the prostatic urethra. If undue force is applied by either hand the recto-vesical sheath may be torn and severe hæmorrhage follow, or the rectum itself may be torn open.

URETHRA

External Urethrotomy

External urethrotomy is seldom performed in those cases which admit of internal urethrotomy, as the advantages of the latter operation are fully established. External urethrotomy, Wheelhouse's operation, is performed in cases of acute retention where no instrument can be passed into the bladder, where fistulæ complicate a stricture, for ruptured urethra, and for extravasation of urine.

Special instruments required are Clover's crutch to maintain the patient in the lithotomy position, Wheelhouse's staff, and a probe gorget.

Position.—The patient is placed in the lithotomy position, with the buttocks at the end of the table, and fixed by Clover's crutch. The surgeon seats himself at the foot of the table.

Operation.—The staff is passed down to the stricture with the groove turned towards the surgeon, and is held in this position by an assistant. An incision is made in the mid line of the perineum over the lower part of the staff *three-quarters* of an inch from its end, and the incision is deepened until the urethra is opened, the knife entering the groove of the staff—the knife should not encroach on the tip of the instrument.

The margins of the urethra are secured with artery forceps and held wide apart. The staff is then reversed so that the button point is exposed and withdrawn to the upper angle of the wound to serve as a retractor. The face of the stricture is now exposed, and a probe-pointed director is passed into the bladder, its groove is turned downwards and a knife passed along the groove to divide the stricture. The probe-pointed gorget is now passed along the groove in the director right into the bladder, dilating the divided stricture to its fullest extent. A catheter may now be passed down the entire length of the urethra and tied in position, or a perineal tube may be introduced through the wound.

Comment.—Great difficulty may be met with in this operation owing to the continuous oozing from the tissues round the urethra

obscuring the view. In rupture of the urethra and extravasation of urine it may be exceedingly difficult to recognize or find the urethra on the bladder side of the rupture ; in some cases even it is necessary to open the bladder above the pubis, and to pass a catheter from the bladder out at the perineal wound—retro-catheterization. The operator should beware of losing patience, gentleness is essential, or the rectum may be wounded, or the recto-vesical space opened up and a pelvic cellulitis started.

OPERATIONS ON THE PENIS

Circumcision

There are many methods of performing this operation, but in children the following directions will be found sufficient.

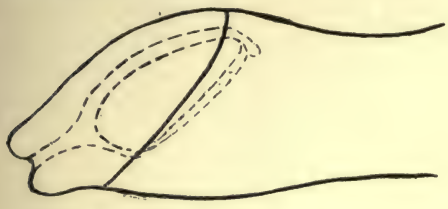


FIG. 151.—CIRCUMCISION.
The incision.

FIG. 152.—CIRCUMCISION.
Sutures in place.

Operation.—The surgeon, standing on the left of the patient, grasps the prepuce between the fingers and thumb of the left hand and draws it forward, when the glans will be felt to slip from the fingers, and the amount which it is necessary to remove can be nicely gauged. With a sharp pair of scissors the prepuce is divided behind the fingers in an oblique manner downwards and forwards so that more is removed from the dorsum than from the under-surface. If forceps are used the prepuce is divided with a knife on the distal side of the forceps. When the penis is thus released the mucous layer remains still covering the glans. The mucous layer is seized with forceps and slit up with scissors, in small children it can easily be torn, along the dorsum. The slit should go back far enough to expose the corona.

The two flaps are taken in turn and any smegma wiped from under them, any adhesions to the glans being freed at the same time. The flaps are trimmed off with scissors about a quarter of an inch from their base on the dorsum but close up

to the frænum below; one is apt to leave too much tissue close to the frænum. The bleeding points are all carefully sought and the vessels twisted, an artery forceps being left on the frænum; it is well to remember that the direction of the frænal artery is backwards from the glans. When all bleeding has been arrested the skin and mucous membrane should be sewn together with fine catgut, interrupted sutures being used, special attention being taken to transfix the frænum and tie the artery with one of the sutures. If the wound is left unsutured it takes very much longer to heal. The wound is dressed with an antiseptic ointment which prevents urine reaching it.

Comment.—This operation is extremely simple, both in adults and children. In adults the tissues are tougher and the bleeding is greater, but in small babies it is more important to secure *every vessel*. If this is not done the vessels retract, and oozing may continue to a dangerous extent. Babies soon become exsanguine, while the hæmatoma which forms renders it very difficult to secure the vessel. The other and lesser danger is removing too little skin so that as contraction of the scar takes place the skin is drawn forward over the glans, and the phimosis is reformed in an aggravated form—the child having to be circumcised again.

Amputation of the Penis

Operation.—A gum elastic bougie is passed down the meatus so that there shall be no difficulty in recognizing the urethra at a later stage in the proceedings. A tourniquet is applied to the root of the penis, for this an elastic catheter is usually used, and is applied behind a needle which is thrust through the body of the organ to prevent the tourniquet slipping forwards.

A rounded skin flap is marked out on the dorsum of the penis, and is then dissected up, it must be of sufficient size to cover in the end of the stump. On the under-surface of the penis an incision is made, passing in a slightly curved manner joining the two ends of the previous incision.

The corpora cavernosa are divided transversely at the level of the base of the flap, commencing on the dorsum. Caution is needed as the corpus spongiosum is approached to avoid injuring the roof of the urethra. The corpus spongiosum containing the bougie can easily be felt and should be dissected away from the under-surface of the distal portion of the severed corpora cavernosa. The corpus spongiosum is divided half an inch in front of the section of the rest of the penis. The bougie can then be withdrawn. The dorsal arteries of the penis are secured together

with any other vessel seen. To prevent oozing from the sinuses of the corpora cavernosa catgut sutures are passed transfixing one side of the fibrous sheath, the median septum, and the fibrous sheath on the opposite side. Three such sutures are enough, and when all are in position they are tied, closing in ends of the corpora cavernosa. The tourniquet is removed and all bleeding points secured.

A small incision is made in the dorsal flap and the end of the urethra is drawn through the opening. The urethra is slit on its under surface and stitched to the margins of the opening. The margins of the flap are stitched to the skin on the under-surface of the penis.

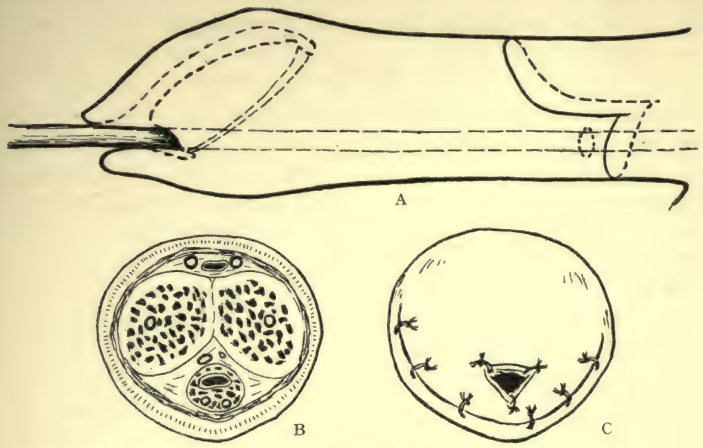


FIG. 153.—AMPUTATION OF THE PENIS.

A, Flap marked on penis. Bougie in urethra; urethra divided in front of flap. B, Cross section of penis. C, Flap sutured in position with urethra brought through the flap.

A collodion dressing is applied after a catheter has been inserted and fixed in position—it should be retained for the first three days.

Comment.—This operation is only partial in nature, and is therefore more often performed on the dead body than on the living subject, where more extensive operations are needed. As recurrence usually takes place in the inguinal glands these must be completely cleared out on both sides at the same time.

The complete amputation is as follows:—An incision is made encircling the root of the penis, this is then extended back through the scrotum to the perineum. A bougie is passed down the urethra, and the corpus spongiosum divided about an inch in front of the triangular ligament, back to which structure it is dissected after

withdrawal of the instrument. The penis is then drawn downwards and the suspensory ligament divided. With a raspatory each crus penis together with its erector muscle is separated from the ramus of the pubis.

This is rather a difficult matter and takes some time. The following arteries must be secured: the two dorsal arteries, the two arteries to the corpora cavernosa, and the two arteries to the bulb, the last are found in the wall of the urethra.

The urethra is slit and sewn to the posterior margin of the wound or a small incision is specially made for it. The scrotal and penis wound are closed after all bleeding has been stayed. A catheter is kept in place and the bowels are confined for the first few days. The inguinal glands are cleared as before.

OPERATIONS ON TESTICLES

Varicocele

Anatomy.—The varicose veins which constitute this condition are those which accompany the spermatic arteries forming the pampiniform plexus. The varicose portion extends from the globus major of the epididymis to the external abdominal ring, through which aperture the blood is returned in one or two large trunks. The enlarged vessels lie in front of the vas and are easily separated from it. The veins accompanying the artery to the vas lie closely connected with that structure and are not affected.

Operation.—An incision one and a half inches long is made over the region of the external abdominal ring, it should never extend more than an inch below the level of the pubic spine. The incision is deepened and the cord exposed, the superficial coverings of the cord are divided and the prominent veins pulled up into the wound. The plexus is then separated from the other structures of the cord, this is easily done if the assistant pushes the testicle into the upper part of the scrotum. When about one and a half to two inches of the plexus have been separated forceps are applied to the two extremities, the lower pair being attached first, the intervening tissue is then cut away. As a rule the spermatic artery is found in the middle of the varicose veins, but this seems of little importance as the artery to the vas is sufficient for the supply of the testicle. Ligatures are applied tightly behind each pair of forceps, the ends of the upper and lower ligatures are tied together. If the strain is judged to be too great, and there seems to be a chance of the ligatures slipping, the union may be reinforced by suturing together the tissue between the ligatures. In this way the weight

of the testicle is largely removed from the vas. The wound is then closed. There is no necessity to remove areas of skin even when the tissues of the scrotum are extremely lax, the wrinkled nature of the skin in this region makes accurate apposition of the wound almost impossible and greatly delays the healing.

Castration

Anatomy.—The testicle is developmentally an abdominal organ which descends to the scrotum from immediately below the kidney, its nervous, vascular, and lymphatic supply are all connected therefore with this level. Malignant disease, whether sarcoma or carcinoma, tends to spread by the lymphatics and not by the vas, so that the lumbar glands become infected. Attempts have lately been made to follow the lymphatics to this region and to clear out these glands so as to obtain a radical cure, but these attempts so far have not proved successful. Tubercle on the other hand usually spreads along the vas towards the base of the bladder. On leaving the internal ring the vas turns round the outer side of the deep epigastric artery, crosses the external iliac vessels, and passing down the lateral wall of the pelvis gains the side of the bladder, it then passes to the inner side of the lower end of the ureter and lies to the inner side of the seminal vesicle. It lies outside the peritoneum all the way. The cord is composed of the following structures :—

(*a*) The vas, which has just been described.

(*b*) Two sets of veins: 1. The pampiniform flexus, which lies some way in front of the vas and carries the blood to the inferior vena cava on the right side but to the left renal vein on the left, into which it opens at right angles. 2. The deferential veins, which accompany the vas closely throughout its course and carry the blood to the vesical venous plexus.

(*c*) Three arteries: 1. The spermatic artery from the abdominal aorta, which becomes tortuous after entering the cord and lies among the pampiniform plexus apart from the vas. 2. The artery to the vas from the superior vesical artery; this accompanies the vas closely all the way to the epididymis, and is capable of supplying all the needs of the testicle. 3. The cremasteric artery, a branch of the deep epigastric, as its name implies, lies among the fibres of the cremasteric covering of the cord.

(*d*) Two sets of nerves: 1. The genital branch of the genito crural which leaves the upper part of the cord. 2. Sympathetic nerves derived from the plexus in front of the aorta.

(*e*) Lymphatics connected with the lumbar glands.

Operation.—An incision is made about two inches long a little to the inner side of the pubic spine. In the case of large tumours the incision may have to encroach on the scrotal tissues, but this should be avoided if possible. If the skin is implicated in the growth, a portion must be removed.

The testicle is pushed up to the wound and the tissues divided until the white tunica vaginalis appears. If fluid is present in the tunica this may have to be drawn off to diminish the bulk before the organ can be delivered out of the wound. When the testis has been extruded from the wound it is grasped and pulled from its attachment to the scrotum, the knife or scissors being used very sparingly to bands of tissue which do not give way easily, all bleeding points being secured at once. Unless there is doubt as to the diagnosis, it is much better not to open the tunica vaginalis for fear of infecting the wound with malignant cells.

When the organ is quite free of the scrotum the cord is drawn down as far as possible, all the structures in front of the vas are separated from that structure, clamped, tied, and cut short. The vas is drawn down and dealt with in the same way. The wound is then carefully closed, room being allowed for drainage.

Comment.—In tuberculous disease the structures of the cord are dealt with as above, with the exception of the vas, which, if infected, is not divided at this stage. The skin incision is continued upwards and outwards above Poupart's ligament, and the abdominal wall is divided in the same manner as described for the ligature of the external iliac artery by Abernethey's method. The deep epigastric artery may be divided and the peritoneum is peeled off the posterior abdominal way and the vas followed inwards as far as practicable. It can be followed almost as far as the base of the bladder. It is then clamped, ligatured and divided. The abdominal wall is then closed in layers.

OVARIOTOMY

Position.—The patient should be placed in the Trendelenburgh position.

Operation.—An incision two to three inches long is made in the middle line above the pubis.

The abdominal cavity is opened in the usual way. Two fingers are inserted and the fundus of the uterus recognized. The

broad ligament is then sought at the side of the uterus, and the fingers arranged so that the ligament is grasped between them; the fingers then travel outwards along the ligament till checked by the ovary. The ovary and fimbriated end of the tube are drawn up to the surface in the grasp of the fingers. The pedicle, consisting of broad ligament, is transfixed and tied by interlocking sutures. Two or at most three are required, one of which includes the Fallopian tube. The ligature material should be strong and the knots tied tightly to prevent slipping; silk is frequently used. The pedicle is grasped by forceps to prevent it slipping, and is divided about one third of an inch distal to the ligatures. The stump is examined to see that all bleeding is arrested and then dropped back into the abdomen.

The ovary on the opposite side can be dealt with in the same way.

The abdominal wound is then closed in the usual manner.

Comment.—In fat people it is difficult to bring the ovary to the surface, and then it is necessary to enlarge the incision towards the pubis and conduct the manipulations inside the abdominal cavity.

In diseased conditions the operation is more complicated, the incision must be more extensive, adhesions have to be dealt with and the greatest care exercised not to tear adherent viscera. In purulent conditions the surrounding peritoneal surfaces must be shut off with gauze, and in these cases a counter opening should be made through the posterior fornix of the vagina, and a drainage tube inserted, the patient afterwards being kept in the sitting posture.

When dealing with large cysts the fluid contents should be withdrawn by a large trochar. When empty the hole in the collapsed wall is closed by forceps and the adhesions to the surrounding viscera are dealt with in the way that seems best. The collapsed cyst is then drawn well up so as to display the pedicle, which is transfixed and secured by interlocking sutures.

HYSTERECTOMY

The removal of the uterus is called for when it is the seat of myomatous change, or when it is affected by malignant disease. These two conditions require very different treatment, as removal of the uterus is sufficient in the former, while in the latter the uterus, appendages, and lymphatics must all be sacrificed.

Instruments.—In addition to the instruments always provided for abdominal work, a volcellum or large cork-screw to fix the uterus, and long-handled artery forceps for the broad ligament should be provided.

Position.—The patient is placed in the Trendelenburgh position. The surgeon usually stands on the left side. The table must be so arranged that a good light falls into the pelvis;

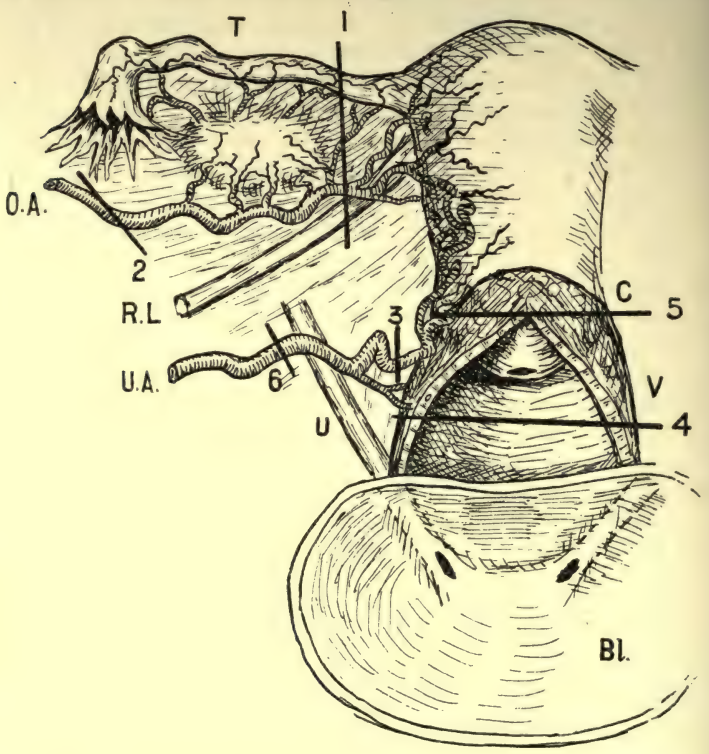


FIG. 154.—THE RELATIONS OF THE UTERUS AND APPENDAGES.

O.A., Ovarian artery. U.A., Uterine artery. R.L., Round ligament. T., Uterine tube (Fallopian). C., Cervix. U., Ureter. V., Vagina. 1, 3, 5, Lines of division in sub-total hysterectomy. 2, 4, 6, In complete hysterectomy.

an artificial light held above and behind the surgeon's right shoulder is very useful.

The operations described are—

1. Sub-total hysterectomy.
2. Total hysterectomy.
3. Hysterectomy for malignant disease.

1. Sub-total Hysterectomy

Operation.—The bladder should be emptied before the operation is commenced. A median sub-umbilical incision is made; its extent varies with the size of the tumour. The tumour is exposed and its nature explored with the hand. Any adhesions are dealt with, special care being given to those of the bladder or intestines; omental adhesions sometimes contain large vessels. The tumour is raised from the pelvis cavity with the hand and delivered out of the wound. A large cork-screw or vulsellum will be found useful in affecting this and in manipulating the uterus later.

The broad ligament is next attended to. Long-handled artery forceps are applied to the Fallopian tube between the ovary and the uterus, grasping the Fallopian tube and the ovarian artery in their grip; two pairs of forceps are applied close together, and the tissues divided between them. Another two pairs are applied lower down, and grasp the round ligament and the anastomotic twig from the deep epigastric artery, which are then divided. Whenever possible, the ovaries should be retained, but when diseased the forceps should be applied to the brim of the pelvis, to the outer side of the ovary, and the Fallopian tube. In septic cases the tubes should be removed with the uterus. In some cases the tumour has separated the layers of the broad ligament to such an extent that the ovary appears to be perched upon the side of the tumour and has to be removed with it. The pampiniform plexus of veins are sometimes of large size, and bleed furiously if torn. The same plan is adopted for securing and dividing the broad ligament on the opposite side. There is no necessity to apply the ligatures at this stage; it is easier and quicker to apply them when the tumour has been removed.

An anterior peritoneal flap is marked out about an inch above the reflexion of the peritoneum on to the bladder, the incision passing from the divided broad ligament on the one side to that on the other. With the finger and blunt-pointed scissors the bladder is separated from the front of the uterus and the cellular tissue opened up between them. In this cellular tissue on each side of the cervix the uterine arteries will be felt or seen; they are accompanied by large veins. The vessels are secured firmly and divided between two pairs of forceps. Great care is taken to avoid the ureters, which lie behind and below the vessels about

half an inch from the cervix. All the vessels known to be supplying the organ are now under control.

The cervix is now cut through from side to side with scissors, the line of section sinking slightly towards the cervical canal. The uterus is then removed. The cervix is examined and, if healthy, can be left. The pelvic cavity is now fully exposed, with three pairs of forceps grasping the margins of the broad ligament on each side of the uterine stump. Ligatures are applied to these in turn, special attention being paid to the two inner pairs which grasp the uterine vessels. These should be under-run by an aneurism needle, which is threaded and withdrawn, leaving the ligature in place. The ligature is tied firmly with three knots. The uterine stump is sewn up by three or four stitches placed antero-posteriorly, avoiding injury to the bladder. These sutures are then buried with a row of Lembert sutures. The cavity of the pelvis is wiped clean and the abdominal wound closed.

2. Total Hysterectomy

This operation differs from the last only in the fact that the whole of the cervix is removed and the vagina opened into; in many cases the sub-total operation is only converted into total removal at the last moment, when it is found on examination that the cervix is in an unhealthy condition.

Operation.—The steps in the operation are the same as in the previous one until the uterine vessels have been secured. The lateral fornix of the vagina is then opened into and the vaginal wall grasped with forceps. The fornix is most easily recognized by getting an assistant to press upon a blunt-pointed instrument placed in the vagina. The vaginal wall is divided all round, and is caught with forceps. Some oozing is to be expected from the lateral angles of the vaginal walls from twigs of the vaginal artery. These may be secured by a mattress suture on each side. The anterior and posterior vaginal walls are united with a continuous suture, and this buried by a Lembert suture in the peritoneal flaps.

In septic conditions only the lateral margins of the vagina are sewn together, a central opening being left for drainage. The pelvic cavity is dried out and the abdomen closed. The vagina should be swabbed out before the patient leaves the table and loosely stuffed with gauze. In septic conditions the patient should be placed in the sitting-up position as soon as possible.

3. Hysterectomy for Malignant Disease

Operation.—The removal of the uterus for malignant disease, according to Wertheim's method, is as follows. If the cervix is affected most of the carcinomatous tissue should be curretted away some days previously and the condition of the vagina made as aseptic as possible. The abdomen is opened by a mesial incision below the umbilicus and the intestines packed out of the way.

The ureters are exposed on the posterior abdominal wall by dividing the peritoneum over the bifurcation of the common iliac arteries; they are followed down towards the bladder by prolonging the incision down the posterior layer of the broad ligament. The bladder is next separated from the front of the uterus, a curved incision being made in the peritoneum over the front of the latter organ. The infundibulo-pelvic, the broad and the round ligaments, are ligatured far out near the side of the pelvis. The uterine vessels are caught by passing the finger along the ureter so that it emerges at the bladder in front of the uterus; the vessels are then raised upon the finger, which protects the ureter while the vessels are ligatured and divided. The lower ends of the ureters are then completely separated from the cancerous cervix.

The peritoneum on the posterior vaginal wall is divided. Bent clamps are applied across the vagina, which is divided below them; the clamps are used to prevent the infection of the wound with cancerous cells.

To clear out all the glands, the peritoneum along the common and external iliac vessels is divided and the extra-peritoneal tissue opened up. Every gland seen is removed from the bifurcation of the aorta to the obturator foramen. The vagina is closed and the flaps of peritoneum united, covering in the raw surfaces. If wished, a drain may be left in the roof of the vagina, the vagina itself being stuffed with gauze. The abdominal wound is then closed. The bladder may be paralysed for some days, and needs attention.

Dangers.—The mortality of the operation is high, about 20 per cent.; it is too early to speak of the remote results. The chief dangers are sepsis, cancer infection, and injury to ureters. There is a great risk of infecting the wound with cancer cells, which grow and may cause death at an earlier date than would the original disease if left undisturbed.

Sloughing of the ureters is the result of actual injury to or

interference with their blood supply. If a uretal fistula forms, a nephrectomy may have to be performed.

CÆSAREAN SECTION

This is the removal of a fœtus and placenta from the uterus by an incision through the abdominal and uterine walls. The operation is performed when the natural passages are so deformed or so blocked by the presence of a tumour that birth of a living child cannot take place through them. It is occasionally performed immediately after the sudden death of the mother where the pregnancy is sufficiently far advanced to allow a reasonable hope that the child may survive.

Operation.—This has sometimes to be undertaken in a hurry and in the most adverse circumstances ; but if the probability of the operation is known, all arrangements can and should be made beforehand. The bladder is emptied and the patient anæsthetised and placed in the Trendelenburg position. A free incision is made from the pubis upwards past the umbilicus. The belly wall is very thin in pregnancy, and the uterus may be cut into before the surgeon is aware that he is in the peritoneal cavity. The assistant slips his hand behind the uterus and grasps the cervix to control the bleeding and to draw the uterus well up to the abdominal wall. A free incision six inches long is made in the anterior wall of the uterus ; if the uterine cavity is opened at the upper part and two fingers introduced, the remainder can be slit down rapidly between the fingers. The hand is introduced and the child brought out, head first if possible, but a foot or an arm may be found more easy to grasp. The difficulty with the after-coming head has always been in those cases where the wound in the uterus has been too small. The bleeding is slight if the placental site is not on the anterior wall ; if the placenta is encountered it may be cut through or the nearest margin sought and the membranes opened there. The bleeding should easily be controlled by the assistant pressing the broad ligaments against the cervix. As soon as the child is delivered, the cord is tied and the placenta and membranes separated. The cavity of the uterus is mopped out, and the finger is pushed through the cervix to make sure there is an escape for the discharges. The uterus contracts strongly as a rule, but if not it can be stimulated to contract by squeezing. The wound in the uterus is closed by a double row of sutures, the first through the whole thickness of the wall, with the exception of the mucous coat ; the second row invaginates the first. The sutures stay

the bleeding from the cut walls. The peritoneum is wiped clean and the abdominal wound closed ; a tight binder is applied over the dressings.

If it is thought advisable to prevent the possibility of a future pregnancy, a ligature should be tied round each Fallopian tube.

VENTRO-FIXATION AND VENTRO-SUSPENSION OF THE UTERUS

These two terms are applied to the operations of fixing the uterus to the anterior abdominal wall in cases of severe retroflexion or prolapse of the organ.

Operation.—The abdomen is opened below the umbilicus in the mesial line ; the hand is introduced and the condition of the parts made out. A cyst may be found in the ovary or a myoma in the uterus, both calling for attention and perhaps causing the retroflexion. The uterus is fixed to the abdominal wall in the following way.

A curved needle threaded is passed through the aponeurosis and adjacent peritoneum on one side of the wound, then through the anterior surface of the uterus near the fundus, a good broad grip of the organ being taken, and finally brought out through the peritoneum and aponeurosis of the other side of the wound. Two or three such sutures are inserted. When they are drawn tight the uterus will be brought to the surface, while the edges of the wound will be approximated. More sutures are needed to support a uterus with a tendency to prolapse than to prevent a retroflexion. The remainder of the wound in the abdomen is closed.

After fixation of the uterus in this way, it is quite possible for the woman to bear children without inconvenience. If there is too much tension on the uterus the adhesions gradually stretch to a suitable length

CHAPTER X

Operations on the Head

Trephining—Mastoid Antrum—Maxillary Antrum—Frontal Sinus—Excision of the Eye

OPERATIONS ON THE HEAD

Surface Markings

The Fissure of Rolando may be marked out as follows. The upper extremity of the fissure corresponds to a point half an inch behind the mid-point of a line drawn from the fronto-nasal suture to the external occipital protuberance. From here the sulcus, which is about three and a half inches in length, extends downwards and forwards at an angle of 67° to the mid-line in front.

If a half sheet of note-paper, which has been folded double so as to mark a transverse crease, be taken and laid on the flat with one side along the middle line of the skull and the crease corresponding to the upper part of the fissure of Rolando, the remainder of the fissure is marked out by doubling the anterior half of the paper down to the crease so as to leave an angle of 45° between the front of the paper and the middle line of the skull in front ; the paper is then again folded down to the crease, and this will now leave an angle of $67\frac{1}{2}°$ between the paper and the middle line of the skull, so that the folded edge of the paper corresponds very nearly with the line of the fissure. In carrying out this manœuvre the student should remember to do it actually on the patient's head, without moving the posterior half of the paper, or, if the paper is removed from the head, to mark previously to its removal the portion which lies along the middle line behind the upper limit of the fissure. If this is not done curious and unexpected difficulties will be met with in attempting to replace the paper.

A " Rolandometer," consisting of two strips of soft metal set at the required angle, can be obtained from the instrument maker.

The line thus marked out lies a little in front of the fissure above and a little behind it below.

The Fissure of Sylvius is marked out, (1) according to Hare

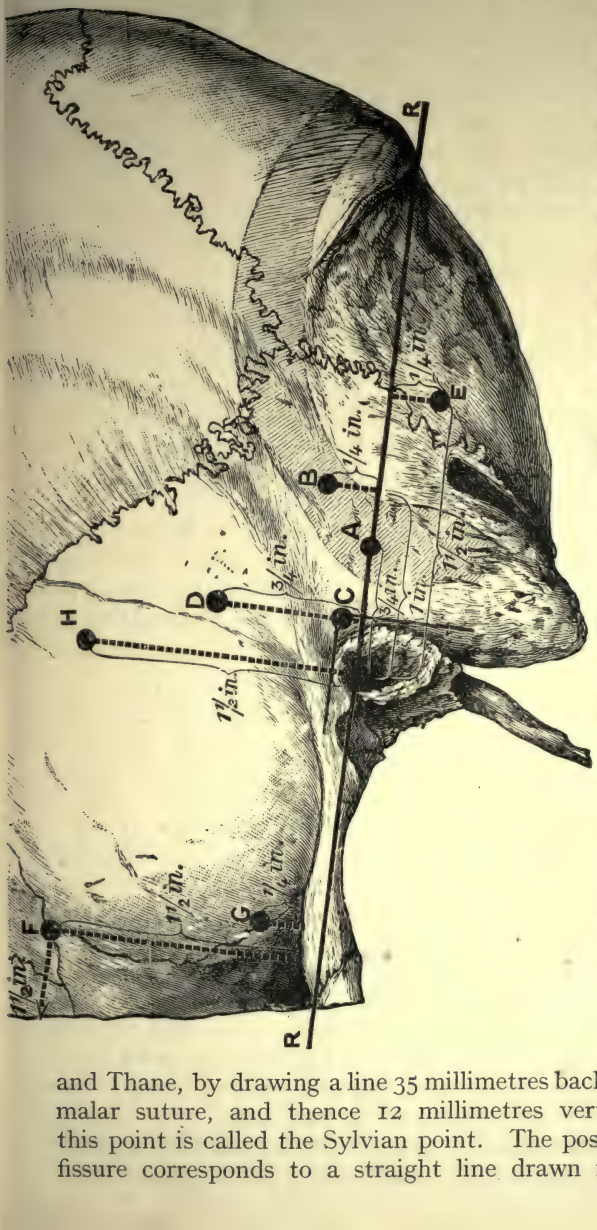


FIG. 155.—DIAGRAM OF ADULT SKULL: NATURAL SIZE, TO SHOW VARIOUS SPOTS FOR TREPHINING (*Rose and Carless*).

The horizontal measurements are taken along Reid's base-line, R R, which passes through the centre of the external auditory meatus; the vertical measurements are taken by drawing lines at right angles to the base-line. A, The sigmoid portion of the lateral sinus, a point ¼ inch along the base-line from the centre of the meatus; B, the transverse portion of the sinus, 1 inch behind the meatus, and ¼ inch above the base-line; C, the mastoid antrum, the point of meeting of two lines—one drawn along the upper wall of the meatus and parallel to the base-line, the other along the posterior wall of the meatus at right angles to Reid's line; D, for temporo-sphenoidal abscess, a line drawn ¾ inch upwards through the posterior border of the meatus at right angles to the base-line; E, for cerebellar abscess, 1¼ inches behind the centre of the meatus, and ¼ inch below the base-line; F, for anterior branch of middle meningeal, 1½ inches behind external angular process of frontal bone, and 1½ inches above the zygoma; G, for posterior branch of middle meningeal, 1¼ inches behind external angular process, and ¼ inch above zygoma; H, for tapping lateral ventricle, 1½ inches above centre of external auditory meatus.

and Thane, by drawing a line 35 millimetres back from the fronto-malar suture, and thence 12 millimetres vertically upwards; this point is called the Sylvian point. The posterior limb of the fissure corresponds to a straight line drawn from the fronto-

malar suture through the Sylvian point to the lower part of the parietal eminence. The anterior limb of the fissure rises vertically for one inch from the Sylvian point. (2) Reid's method is rather less accurate than the last; he draws a line from a point one and a half inches behind the external angular process of the frontal bone and one and a half inches above the zygoma to a spot three-fifths of an inch below the most prominent part of the parietal eminence. The undivided part of the fissure is represented by the first three-quarters of an inch, and from here the anterior limb is given off vertically for an inch.

The Parieto-Occipital Fissure comes to the outer surface of the brain almost exactly at the Lambda, and can be marked out by prolonging Reid's line for the fissure of Sylvius back to the mid-line posteriorly.

The whole of the motor area is now known to be situated in front of the fissure of Rolando, the areas being, from below upwards, the face, arm, trunk, leg. It is unnecessary to attempt to ascertain exactly the precise markings of these areas on the surface of the skull, as surgeons now do not confine themselves to the removal of small trephine discs, but freely expose the area to be investigated.

The Sub-Arachnoid Space may be opened and drained (1) in front at a point midway between the fronto-malar suture and the Sylvian point as the arachnoid bridges across the stem of the fissure of Sylvius from the anterior end of the temporal to the posterior part of the frontal lobe. A small trephine must be used, or the middle meningeal artery may be injured.

(2) Posteriorly, the cisterna magna or space between the under surface of the cerebellum and the posterior surface of the medulla may be opened. To do this a flap of soft tissues is turned down as in exposure of the cerebellum, and a disc of bone removed a little above the foramen magnum.

The Superior Longitudinal Sinus extends in the mid-line from the glabella, where it communicates with the veins of the nose to the occipital protuberance, where it becomes continuous with one of the lateral sinuses, usually the right.

The sinus becomes broader as it extends backwards, while in the region of the posterior superior angle of the parietal bone are the para-sinoidal sinuses into which open the parietal emissary veins and in which are situated many Pacchionian bodies; here the sinus may easily be wounded, and great care should be taken in removing bone within an inch of the mid-line.

The Lateral Sinus passes in a gentle curve with the convexity upwards, from above the external occipital protuberance (Reid's

base-line is a quarter of an inch below the protuberance) to about the middle of the mastoid process. Its highest point grooves the posterior inferior angle of the parietal, three-quarters of an inch above Reid's base-line. From a point about three-quarters of an inch below and behind the centre of the auditory meatus the sinus turns inwards to the jugular foramen.

The right sinus is usually the larger, as it is the continuation of the longitudinal sinus, and therefore extends further forwards in the mastoid process. The position of the lateral sinus in

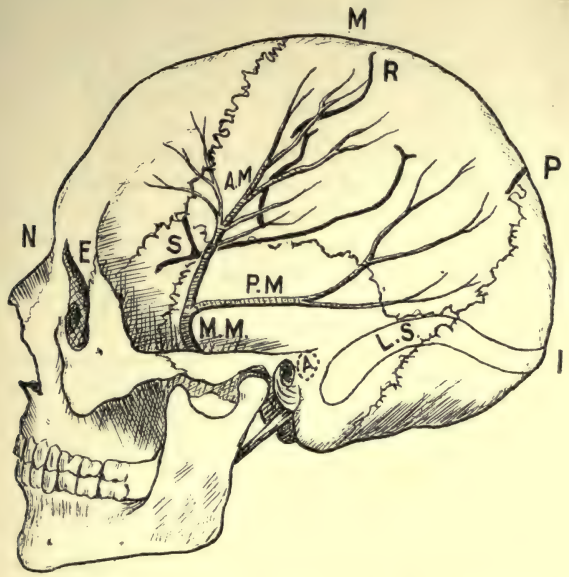


FIG. 156.—SURFACE MARKING OF THE HEAD.

I., Inion or ext. occipital protuberance. N., Nasion. M., Mid point between I and N. R., Fissure of Rolando. E., External angular process. S., Sylvian point where the three limbs of the fissure meet. P., Parieto-occipital fissure. M.M., Middle meningeal artery. A.M., Anterior branch. P.M., Posterior branch. L.S., Lateral sinus. A., Mastoid antrum.

the mastoid process varies from three-eighths to fully one inch from the posterior wall of the external auditory meatus (MacEwen). It also varies in its depth from the surface. In wounds inflicted on the venous sinuses the bleeding is usually very free owing to the inability of their walls to collapse; fortunately the blood pressure is low, so the hæmorrhage is easily controlled by plugging.

The Middle Meningeal Artery is a branch of the first part of the internal maxillary; it enters the skull through the foramen

spinosum, and after a course of about one and a half inches it divides into an anterior and a posterior branch, at a point which varies from a quarter to half an inch above the middle of the zygoma.

The anterior branch runs upwards on the anterior part of the squamous temporal to the pterion, where it enters a deep groove, often even a canal, on the anterior inferior angle of the parietal bone. From here it runs upwards and backwards almost parallel to the anterior border of the same bone, giving off its larger branches upwards and backwards, only a few passing on to the frontal bone. This branch is particularly liable to injury as it adheres firmly to the dura, so that any force tending to separate the dura from the bone is liable to tear the artery where it lies imprisoned in the deep canal at the anterior inferior angle just above the pterion.

The pterion can readily be found by taking a point one and a-half inches behind the fronto-malar suture, and two inches above the zygoma; if the pin of a half-inch or three-quarter inch trephine be applied here, the disc of bone removed will certainly show on its deep surface the canal in which the artery has lain. Another recommendation to expose the vessel is to trephine two inches above the middle of the zygoma.

The posterior branch of the artery runs backwards horizontally from its origin and then turns upwards on to the posterior part of the parietal bone. To expose it a small trephine should be applied as near the zygoma as the flap of soft parts will allow.

Trephining the Skull to expose the Middle Meningeal Artery

Trephining the skull is such an important operation that it cannot be practised too often. The principles of the operation are the same whatever part of the skull is involved, but to avoid repetition, the method will be fully described in the operation for exposing the middle meningeal artery.

Operation.—The patient lies on the back with the head turned so as to expose the affected side, sandbags are used to steady the head. The fronto-malar suture and the zygoma are identified and the necessary measurements (one and a half inches back and two inches up from these two points) made to find the pterion. This point is then marked on the bone by an awl thrust straight through the soft parts. A horseshoe-shaped flap, with the base towards the zygoma, of sufficient size to leave plenty of room should additional bone have to be removed, is marked out with the knife and deepened down to the bone.

With a periosteal elevator the whole of the soft parts including the peri-cranium, are detached downwards. A trephine, either half or three-quarters of an inch in diameter, is applied with the pin at the point previously marked on the bone. The modern instrument should be used, with the serrations carried up on the outer side and with a pin which can be removed completely. The head is held while steady movements of supination and pronation are made; it is during the former movement that the bone is cut. The instrument should be held firmly but not pressed too heavily on the bone. As soon as a complete circle has been sunk the pin can be removed and the sawing continued.

FIG. 157.—INCISIONS ON HEAD AND NECK.

1, Middle meningeal artery. 2, The facial artery. 3, The lingual artery. 4, The external carotid. 5, The common carotid. 6, The third part of the subclavian. 7, The first part of the axillary. H, Hyoid bone. C, Coracoid.

From time to time the trephine should be removed and a needle or quill used to ascertain the depth of the cut. As soon as the dura can be felt anywhere the instrument must be tilted so that no further cutting takes place at that point. The bone in the region of the pterion is of unequal thickness, being thicker below and in front where the lesser wing of the sphenoid joins the side of the skull. When the bone is almost completely divided gentle attempts to raise the disc should be made with an elevator. When the disc of bone is removed its under-surface should be examined to see if the marking of the artery is imprinted upon it. The artery is seen on the surface of the dura, and can be under-run by an aneurism needle and secured.

When hæmorrhage has taken place a dark clot will be revealed which must be broken down and washed out before the dura becomes visible; if the artery is seen and can be secured this must be done. If the artery has been torn across and has retracted into the bony canal, the bone should be bitten away with strong forceps until the vessel can be seen, the vessel may then be secured and tied, which is no easy matter, or the canal plugged with wax. A simpler method, however, is to follow the

canal down till the artery can be seen and then to take a good bite of the bone with forceps and to apply just sufficient pressure to crush in the wall of the canal and so occlude the artery. The area is then inspected to see that there is no further bleeding, and the flap is replaced and stitched in position, drainage if thought necessary being allowed at one end of the incision. There is no advantage to be obtained from attempting to replace the bone which has been removed.

Comment.—In using the trephine one should remember that individual skulls vary greatly in thickness, it is therefore wise to observe the old rule of considering the skull operated upon to be specially thin, and frequently to remove the instrument and probe the depth with a quill. In this way the dura will escape injury. The unequal thickness of the skull even within the limits of the trephine disc must also be borne in mind. Too much pressure should not be applied to the instrument.

In trephining in order to elevate a depressed fracture, the instrument is never applied to a loose or a depressed piece of bone, but always to a firm piece at one side of the depression.

Osteo-plastic Flaps are sometimes used to expose large areas of the brain. They are not used so much now as formerly as their advantage is very doubtful. The operation can be performed in two ways, either by the chisel and mallet or by the saw.

1. *By Chisel and Mallet.*—A large horse-shoe flap is cut through the scalp, but the flap is not detached and thrown down. With a chisel and mallet the bone is divided all along the tracks of the knife. A narrow chisel partially divides the bone at the base of the flap by undermining the soft parts. The bone is fractured along the base line by prising it up with an elevator; it is then thrown downwards still attached to the scalp.

It is extremely hard to divide the skull with a chisel without injuring the dura, and the prolonged hammering is calculated to increase the shock of the operation.

2. *With the Trephine.*—A flap which is almost rectangular is marked out with the knife and left in place as before. Four small trephine holes are made, one at each corner. The dura mater is then separated from the inner table of the bone by passing a narrow piece of whalebone from one trephine hole to the other.

A special guide is slipped along the whalebone, or the guide may be used first and the whalebone passed along it. To the whalebone is attached a piece of stout silk, which is caught at the other trephine hole and to this a Gigli saw is attached and drawn into place along the guide. The guide is kept in place

to protect the dura while the bone of that side is being sawn through. The same manœuvre is repeated for the three sides, which are completely divided, the base is only partly divided, the remainder being fractured.

After the operation the flap with the bone attached is replaced and sewn in position. If the area of operation is not wide enough, additional incisions must be made through the soft parts, which are then reflected and the bone nibbled away with powerful forceps.

The operation is tedious as it is difficult to pass the guide through small trephine holes, and if they are large it is probably quicker to nibble away the intervening bridge of bone or to cut the bone with an ordinary saw, taking great care of the dura; both these methods leave the base to be divided with the Gigli.

Puncture of the Lateral Ventricle of the Brain

This is usually done with an exploring syringe through a small trephine opening in the skull; the needle of the syringe should be at least two and a half inches long. It is extremely difficult to enter the normal ventricles with any certainty, but little difficulty is met in entering them when distended with fluid.

Keen's method is to puncture one and a quarter inch (3 cm.) above and behind the external auditory meatus, the ventricle being reached at a depth of two inches (5 cm.). By means of a similar opening on the opposite side he was able to wash through both ventricles.

The puncture is made directly towards the tip of the opposite auricle. The drawback in this operation is that the ventricle is entered in its narrowest part, and the needle may easily pass through the space into the brain on the far side.

Kocher, for this last reason, preferred to puncture downwards and backwards from just in front of the bregma, three-quarters of an inch (2 cm.) from the middle line, the ventricle being entered at a depth of two inches.

OPERATIONS ON THE EAR

Anatomy.—The mastoid antrum, situated in the upper and anterior part of the mastoid process and present from birth, is very constant in its position, but varies greatly in size and in its depth from the surface.

The antrum is in direct communication with numerous small

air cells with which the rest of the mastoid is honeycombed, and these are always involved in septic diseases of the antrum.

The relations of the antrum are as follows:—

In front.—At its highest point it communicates with the attic of the middle ear by means of the iter or aditus ad antrum, a narrow passage about a quarter of an inch long. The inner wall and floor of the iter is formed of compact bone encasing the facial nerve, while the external semi-circular canal causes a slight bulging of the inner wall posterior to the facial canal. Below the iter the facial nerve runs vertically in its canal to the stylo-mastoid foramen, the canal lying in front and slightly to the inner side of the antrum.

Behind the antrum lies the sigmoid sinus and the cerebellar fossa. The antrum itself when large, or in other cases the air cells, usually extend backwards in close connection with the vertical portion of the sigmoid sinus. The position of this portion of the sinus is inconstant, "being sometimes within three-eighths of an inch of the posterior osseous wall of the external auditory meatus, and at others fully one inch behind it, while it also varies much as to depth from the surface" (MacEwen). When the air cells extend far back behind the sinus they are only separated from the cerebellar fossa by a very thin plate of bone.

Above the antrum and iter are roofed in by the thin plate of the tegmen tympani which separate it from the middle fossa of the skull, the membranes and the temporo-sphenoidal lobe of the brain.

The floor and outer wall of the antrum are in connection with many air cells which may honeycomb the mastoid, and may even open on the surface naturally (Bezold's opening), or more frequently by a process of caries. On the other hand, especially after long standing inflammation, the bone may be sclerosed and contain but few cells.

With all these important structures in the neighbourhood it is important to be able to strike the antrum with certainty and safety, this it is easy to do if the opening is confined to the supra-meatal triangle (MacEwen's triangle). This triangle is marked out by two intersecting tangents, one drawn backwards from the upper margin of the external auditory meatus, and the other drawn upwards from the posterior margin of the meatus. The first tangent practically corresponds to the posterior root of the zygoma. The triangle thus marked out is often indicated by a well marked depression in the bone. The supra-meatal spine or spine of Henle when present is always included in this triangle.

An opening made straight in through this triangle at right angles to the surface of the bone will invariably reach the antrum and, provided the opening is not large, it will avoid both the sinus and the dura mater.

Exploring the Mastoid Antrum

Operations.—The head is turned so that the affected side is uppermost, it is then fixed and supported with sandbags.

A curved incision is made from just above the auricle to the tip of the mastoid process, so as to lie about half an inch behind the attachment of the ear. The incision is deepened down to the bone and the flap and ear detached forwards with a periosteal elevator, so as to expose the posterior wall of the external osseous meatus. Occasionally while doing this the mastoid emissary vein will be torn and have to be secured. The pinna is held forward out of the way either with a retractor or a stitch. The supra-meatal triangle is then clearly defined and the removal of the bone commenced.

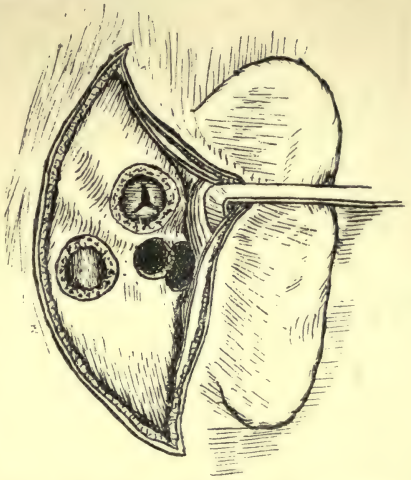


FIG. 158.—RELATIONS OF THE MASTOID ANTRUM.

The mastoid antrum opened, the lateral sinus exposed, the dura of the middle fossa exposed and opened.

The usual plan (especially in examination) is to cut in with a mallet and fine gouge or chisel, the bone being removed in thin flakes, the more superficial portion of the cut commencing behind or above the level of the triangle, but the deeper portion being strictly confined to that area, the chisel or gouge being held so that it slopes towards the surface of the mastoid; it should never be held at right angles to the surface of the bone. When once the mastoid is opened great care must be taken not to wound the canal of the facial nerve.

Exposure of the antrum by means of a small trephine is scarcely ever performed now as the operation is a perfectly blind one.

Exposure with a suitable burr is very safe, and as with the

gouge the sinus can be recognized as soon as it is exposed or the canal of the facial nerve can be identified by its dense bone so that accidents are avoided.

When the pus has been evacuated the further steps of the operation can be decided upon. As a rule a considerable portion of the superficial surface of the mastoid process is removed and the septic mastoid cells exposed and all the cavities thrown into one.

The Complete Operation.—The removal of the outer wall of the iter and throwing the antrum and typanum more widely into one is called Stacke's operation, or the complete operation.

A Stacke's protector is pushed into the iter from the mastoid and lies under the portion of bone to be cut away and protects the inner wall of the iter where lies the canal of the facial nerve. When the protector is in position the chisel and mallet can be used with confidence and the bone removed. The middle ear can now be cleared out and the diseased malleus and incus removed.

Exploring the Middle Fossa and the Tempero-Sphenoidal Lobe

Having performed the complete operation, the student should be made to cut away additional bone so as to expose the middle fossa above and the lateral sinus behind so that an accurate idea is gathered of the relations of these structures. Further bone can be removed if necessary with nibbling forceps.

When an abscess is thought to be present in the tempero-sphenoidal lobe, the middle fossa having been exposed, the diagnosis is rendered more likely by the presence of caries of the tegmen tympani or by meningitis which has glued all the membranes together. The membranes are incised and the interior of the brain explored with sinus forceps which are introduced for about one inch in various directions, and the blades slightly separated to allow the pus to flow out. A trocar and canula should not be used as the pus is often too thick to escape along the tube, the instrument also may pass through the abscess into the brain beyond. A tube should be inserted for drainage, but flushing out is not advisable.

Exploring the Lateral Sinus and Cerebellum

If this is thought necessary, an incision can be made passing backwards in a curved manner from the middle of the original incision. The soft parts are then detached from the bone. If the pin of a one-inch trephine is applied one and a quarter

inches behind the middle of the meatus and a quarter of an inch up, then on removing the disc of bone the sinus will be seen with a portion of the middle and posterior fossæ showing respectively above and below it. On removing more bone both these fossæ can be explored. If a blood clot is found in the sinus on inserting a hypodermic syringe the jugular vein should be exposed and divided in the neck below the clot. The clot can then be broken up and removed by flushing. The vein is then tied and the sinus plugged.

EXCISION OF THE EYEBALL

As excision or enucleation of the eyeball is the only operation on the eye that the student is likely to be asked to perform, it will be the only one described here. All other operations on the eye or the eyelids belong more to the ophthalmic than to the general surgeon, and special text books on the eye must be consulted for their description.

Indications.—

1. New growths, such as glioma of the retina, melanotic sarcoma or carcinoma of the uveal tract.

2. As part of the operation for the removal of new growths in the neighbourhood, such as rodent ulcer, sarcoma, carcinoma, or bony growths in the region of the orbit.

3. Injury to the eye, such as—

(*a*) Rupture and collapse of the eyeball.

(*b*) Wounds of the dangerous area which have destroyed the sight of the eye. The dangerous area being a zone of about a quarter of an inch surrounding the corneo-sclerotic junction.

(*c*) Wounds of the dangerous area which have already set up irido-cyclitis.

(*d*) Wounds of the dangerous area complicated with traumatic cataract.

(*e*) Wounds of the dangerous area with pan-ophthalmitis supervening.

(*f*) The presence of a foreign body in the eye which is not removable without disorganization.

The object of the operation is to leave a stump of conjunctiva and the matted ends of the muscles of the eyeball which shall form a movable support for the glass eye to rest on. In wounds of the dangerous area the eyeball has to be removed with the object of preventing sympathetic changes taking place in the opposite eye when the sight in the exciting eye has been destroyed.

It should be mentioned that when the wound of the exciting eye does not destroy sight and produces no very great changes, the ultimate result may be that better sight remains in the exciting than in the sympathising eye, and this should be carefully considered before excision is decided on.

Instruments.—Blunt-pointed scissors, straight and curved artery forceps, strabismus hook, toothed dissecting forceps, spring speculum. The operation may be performed with toothed dissecting forceps and straight scissors.

Position.—The patient lies on the back with the head slightly raised on a pillow. The surgeon stands on the affected side.

Operation.—The spring speculum is inserted and the conjunctiva divided all round close to the cornea, freely opening Tenon's capsule. With the strabismus hook the external rectus is drawn forwards and divided close to the globe. The superior and inferior rectus muscles are drawn forwards and divided in the same way. The stump of the external rectus attached to the eyeball is now held with forceps, and the globe rotated inwards, while a curved pair of forceps is introduced into the cavity of the orbit and the tough optic nerve felt for and divided. The eyeball is then drawn out and the remaining tendons divided. The cavity is then rapidly plugged for a few minutes to arrest the hæmorrhage which may be free. The plugging may then be removed and any spurting point caught with forceps and tied. If the operation is performed for malignant growth of the eyeball the optic nerve should be cut as short as possible as the growth extends back along the course of the nerve. The cavity is washed out with boracic and plugged for twenty-four hours, firm pressure by means of a pad and a bandage being applied.

After-treatment.—The eye should be dressed every day, and the plugging gradually left out as the cavity granulates up.

A glass eye may be inserted, if all goes well, at the end of a fortnight ; but should not be worn constantly for at least a month, as by its irritation it is liable to set up conjunctivitis.

CHAPTER XI

Operations on the Breast

Anatomy of the Breast

The breast consists of about fifteen lobules separated by fibrous septa, which converge upon the nipple. The organ is enclosed in a fibrous capsule, which is closely connected with the skin by the suspensory ligaments of Cooper, and loosely connected with the fascia and aponeurosis of the muscles upon which it rests. The gland varies in size, but can be said to extend from the second interspace above to the sixth interspace below. Externally the gland spreads out to the middle of the axilla, in which semi-detached lobules may be found. Protruding portions may also be found between the fibres of the pectoralis major. The arterial supply is derived from (1) the long thoracic branch of the axillary artery; (2) the anterior perforating branches of the internal mammary artery through the second, third, and fourth spaces; (3) the lateral branches of the second, third, and fourth intercostal arteries.

The lymphatics of the breast are important as along them carcinomatous cells are carried from the primary growth. The superficial lymphatics in the capsule of the gland converge towards the nipple, having many communications with the skin lymphatics by means of the suspensory ligaments. The deep lymphatics throughout the breast lie in the fibrous tissue between the lobules, they too converge on the nipple, having many connections with the superficial lymphatics. The efferent lymphatics start mainly from the lymphatic plexus around the nipple, and, passing deeply, leave the under-surface of the breast capsule; from here they run in many directions.

1. The main and most important lymphatics run upwards and outwards along the pectoral group of axillary lymphatic glands to the glands in the apex of the axilla. From there the lymph passes to the deep glands above the clavicle and eventually passes

into the general blood stream by the thoracic or by the right lymphatic duct. To reach the pectoral lymphatics in the first place the lymph may pass (*a*) round the lower border of the pectoralis major muscle ; (*b*) in the fascia of the muscle ; or (*c*) may actually pierce the substance of the muscle.

FIG. 159.—DIAGRAM TO SHOW THE LYMPHATIC FLOW FROM THE BREAST.

2. Lymphatics leaving the deep surface of the outer portion of the gland, may pass to the subscapular group of axillary glands, and through them flow into the glands at the apex of the axilla as before. Lymph may also pass into the chest wall with the lateral tributaries of the intercostal veins, and so to the back of the thorax.

3. Lymph from the inner portion of the breast may pass back to join the mediastinal lymphatics with the anterior communicating tributaries of the internal mammary vein through the second, third and fourth interspaces. There is also a fairly free anastomosis across the middle line with the lymphatics which enter the mediastinum through the corresponding spaces of the opposite side. There is also a communication with the lymphatics of the opposite breast.

4. Lymph from the lower and inner part of the breast may drain downwards through vessels in the aponeurosis in the external oblique to the angle between the sixth costal cartilage and the ensiform cartilage, and there turn into the mediastinum through the same opening as that by which the superior epigastric emerges.

5. The lymph from the upper part of the breast may pass directly upwards superficial to the clavicle to enter glands situated at the lower end of the external jugular vein.

Normally most of the lymph is drained away from the breast by the main vessels along the lower border of the pectoralis

minor, but in carcinoma, as soon as these lymphatics become obstructed either by blockage with malignant cells or by the contraction of the fibrous tissue round about, the other routes open up and take on the function of the blocked vessels.

Abscess of the Breast

Abscess forms as the result of infection of one or more lobules by micro-organisms, which gain access through the ducts which open at the nipple. The incision should be made over the infected lobules in a manner radiating from the nipple, so as to avoid cutting across the ducts of uninfected lobules. The septa between the pockets of pus in adjacent lobules are all broken down, so that all drain freely through the one wound. Tubes are inserted and counter openings made if necessary. The wound must heal by granulation.

Sub-Mammary Abscess

In this form of abscess, the pus collects in the loose cellular tissue between the breast capsule and the underlying muscles. The origin of the abscess is usually altogether outside the breast, and is more usually in connection with the ribs and chest wall.

To evacuate this a circumferential incision is made below and to the outer side of the breast in the fold formed by the breast and the chest wall. The incision is deepened till the muscles are seen, the breast is then lifted forwards and the abscess opened by inserting a pair of forceps underneath the organ. The capsule of the breast should not be opened. A drainage tube is inserted, and the cavity drains at its lowest part.

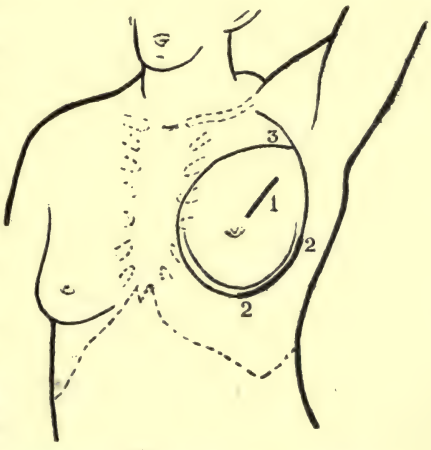


FIG. 160.—INCISIONS OF THE BREAST.
1, Incision radiating from the nipple. 2, 2, Circumferential incision. 3, An incision for removal of the breast.

Adenoma of the Breast

An adenoma may be removed from the breast in one of two ways.

1. By cutting down over the lump with an incision radiating from the nipple so as not to injure the ducts of the gland. The wound is deepened until the capsule of the adenoma is seen. The capsule is opened and the adenoma shelled out. The wound is then closed.

2. If the scar of the wound just described would be visible when wearing a low-necked dress, it is better to remove the tumour through the deeper surface of the breast. As in submammary abscess a circumferential incision is made at the lower and outer part of the breast. The lower border of the gland is defined and lifted forwards, while the upper part is depressed into the wound. In this way the posterior surface of breast is exposed. A radiating incision is now made over the tumour through the exposed under-surface, the capsule is opened, and the growth removed. The breast is allowed to fall back into position and the wound sutured. There is very little bleeding met with in the operation.

Removal of the Breast for Carcinoma

The radical operation for malignant disease of the mamma aims at the removal of the whole organ, all the lymphatic glands and vessels which are likely to be infected, together with the tissues through which the lymphatics run. The operation therefore includes the breast, the pectoralis major, a part of the aponeurosis of the external oblique, the fascia over the sternum, serratus magnus, and over a part of the latissimus dorsi, together with all the three groups of lymphatic glands in the axilla. All these tissues should be removed in one piece so that the lymphatic vessels are cut across as far from the growth as possible so as to avoid malignant cells escaping into the wound. Occasionally it may be necessary to remove the pectoralis minor muscle as well, but in the majority of cases this muscle may be spared, together with the clavicular portion of the pectoralis major.

Operation.—1. *The Incisions.*—Various incisions may be used; they should all pass wide of the growth and of any skin that appears to have become adherent to the breast. The incisions must extend from the near costal angle up over the axilla, the upper part usually curves along the groove which marks the adjacent borders of the pectoralis major and

the deltoid. The outer incision is marked out before the inner. The skin of the outer flap is dissected up thinly, the knife passing through quite the superficial layers of fat until it is well over the back of the latissimus dorsi. The skin of the inner flap is dissected up thinly in the same way, until the knife has passed as high as the clavicle above and well across the sternum in front. At the lower end of the incision the undercutting should proceed well beyond the ensiform cartilage.

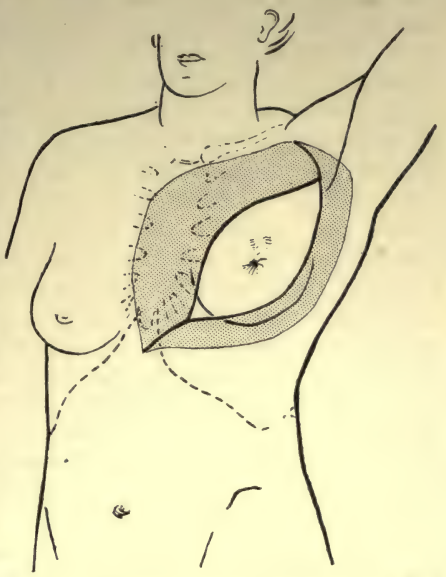


FIG. 161.—INCISION FOR REMOVAL OF THE BREAST.

The shaded area shows the under cutting of the skin.

2. *The Dissection.*—The edge of the knife, which has been directed rather towards the skin, is now turned towards the chest wall and the subcutaneous fat divided to expose the origin of the pectoralis major of the opposite side. The fascia of the inner part of this muscle and of the front of the sternum is dissected towards the affected side; a few perforating branches of the opposite internal mammary artery have to be secured and divided. The fascia is taken off in one piece until the pectoralis major on the affected side is exposed. The origin of the muscle from the sternum and costal cartilages is detached. The perforating branches of the internal mammary artery should be secured in each space, if possible, before they are divided, as they are difficult to catch once they have retracted into the chest wall. At the lower end of the incision the aponeurosis of the external oblique is divided and dissected up, exposing the upper part of the rectus abdominis. The whole of the fascia is cleared upwards from the serratus magnus muscle and forwards from the latissimus dorsi muscle, towards the axilla. If the clavicular portion of the pectoralis major is to be removed it is divided close to the clavicle. As the muscle is drawn outwards the pectoralis minor comes into view. If this is to be removed it is reflected from its origin—as a

rule it can be spared. The external anterior thoracic nerve and branches of the thoracic axis vessels are secured and then divided. The tendon of the pectoralis major is cut about an inch from its insertion, the arm being rotated inwards. The insertion of the pectoralis minor is detached from the coracoid process and drawn inwards so as to expose the whole of the contents of the axilla.

3. *The Axilla.*—The partially detached breast is supported by an assistant, and the large raw surface of the chest wall is covered with cloths wrung out in warm saline. The fat in the very apex of the axilla is torn through, exposing the axillary vessels and cords of the brachial plexus. All the fat and lymphatics are separated by gauze dissection. This is done by wiping all the fatty tissue from the vessels and nerves from above downwards with a piece of gauze. Attention must be paid to certain structures such as the subscapular nerves, especially the long subscapular and the nerve of Bell, all of which supply important muscles. The intercosto-humeral nerve is liable to injury, but is not of much importance. As soon as these structures are identified, the remaining adipose tissue may be cleared rapidly from the axilla. All vessels are caught before they are divided, and very little blood is lost. All the fat is cleared from the inner surface of the subscapularis and latissimus dorsi muscles, and especially along the course of the subscapular vessels. When the axilla is cleared the whole mass of the tissues is removed by the assistant. The wound is washed with hot saline to stop the oozing, and is then examined to see that nothing of a suspicious nature has been left. A few ligatures are required for the veins which have been divided close to the axillary vein. From the remainder of the vessels the forceps can simply be removed, or a few twists given. The tendon of the pectoralis minor can be re-attached to the coracoid process by catgut sutures.

4. *Closure of the Wound.*—The margins of the wound are sutured together, starting from the extremities, where there is little tension. As the wide part of the wound is approached, strong tension sutures will be necessary. The arm is brought to the side and the opposite breast pushed over, so as to relax the parts. When the tension sutures are in place finer sutures are inserted between them. A special opening is made for drainage just in front of the tendon of the latissimus dorsi, and a tube put up into the axilla.

After-treatment.—Firm bandages are applied round the chest and over the shoulder. The arm may be fixed in a sling or placed at right angles to the body by tying the wrist to the head of the bed. Free movement should be accorded to the arm at once,

and on no account should the limb be fastened to the chest. There is considerable shock after the operation, but very little pain.

NOTE.—Some surgeons prefer to carry out the operation in the reverse order, dividing the insertions of the pectorals and clearing out the axilla first, and removing the tissues from the chest wall last. When the pectoralis minor can be left, the author is accustomed to suture its tendon to the divided tendon of the pectoralis major, or to the clavicular portion of that muscle if it also is spared. In this way the action of the muscle can be transferred to the arm.

Even more radical operations than the one described, are sometimes performed, the incision being carried up over the clavicle to expose the posterior triangle of the neck. The clavicle is divided and the whole length of the axillary vessels exposed, together with the third part of the subclavian artery. All the lymphatics from the lower part of the posterior triangle are removed in addition to those of the axilla. The divided ends of the clavicle are subsequently wired together. In cases where such a wide area of skin has been removed that the edges of the flaps appear anæmic and likely to slough, the tension can be relieved by carrying an incision backwards and downwards for a variable distance from about the mid-point of the posterior flap; this portion of skin is undercut and will then slide forwards (Fig. 162). Skin grafting is another method of covering in the areas over which the flaps cannot be drawn, or having been drawn have subsequently sloughed.

FIG. 162.—METHOD OF RELIEVING TENSION AFTER THE OPERATION BY A CURVED INCISION TOWARDS THE BACK.

(See Plastic Surgery.)

CHAPTER XII

Operations on Hare-lip and Cleft Palate—Plastic Surgery —Skin Grafting

HARE-LIP

The Age to Operate.—The rough rule generally accepted as a guide to the best time to operate on children with hare-lip or cleft palate is to close the hare-lip before the troubles of dentition commence, and to close the cleft in the palate before the child learns to speak. Children with cleft palate are, as a rule, very backward in learning to speak. This means that the hare-lip should be closed before the seventh month, and the cleft palate before the child is two and a half to three years old.

The reasons for not subjecting a very young infant to a severe operation are—

1. That it has hardly got over the change from an intra-uterine to an extra-uterine life.

2. The mortality of all children is much higher in the first three months of life than later. In children with these deformities some intercurrent disease such as diarrhœa or lung trouble is apt to carry them off.

3. That deformed children are, as a rule, more weakly than those not so deformed.

Although authorities are more or less agreed as to the advantage of operation before dentition in the case of hare-lip, a great divergence of opinion exists as to the correct time to operate in cleft palate. This is largely due to the different methods of operating adopted by different surgeons.

And while the rule to leave the cleft till the child is in his third year is generally held by those who perform the old operation, there is a distinct advantage in operating early if a flap operation is to be performed. Mr. Lane prefers to operate as soon after birth as possible, certainly before the teeth erupt, so that the tissue covering the alveolar margin may, if necessary, be used to close the cleft in the palate. If hare-lip and cleft palate co-exist, and the cleft palate is to be closed while the child is young,

a few months old, the hare-lip should be left untouched till the palate has been attended to, as thereby much room is gained in which to work.

Operations for Hare-Lip

Position.—The infant is well wrapped up in a blanket with its hands by its side, and lies on its back. The anæsthetic is given through a tube by means of a Junker's inhaler. The position of the surgeon will vary with the individual, some like to sit at the patient's head, some on his right side.

Instruments.—A narrow-bladed, sharp-pointed knife, toothed dissecting forceps, scissors, sharp and blunt-pointed, artery forceps, fine, straight needles, ligature and suture material. A gag should be kept handy, and there should be plenty of small sponges mounted on artery forceps.

1. Single Hare-Lip

Operation.—Only the main features of the operation can be described, as the actual details will vary with the extent and nature of the cleft. The operation can be conveniently divided into three stages:

1. Freeing the lip.
2. Paring the edges of the cleft.
3. Closing the cleft.

1. *Freeing the Lip.*—The lip is lifted up and with the scissors the reflection of the mucous membrane to the upper jaw on each side is very freely divided, the scissors being kept close to the bone. The blood is mopped away with sponges and prevented as far as is possible from running back into the mouth and nose.

2. *Paring the Cleft.*—The lip is held steady while the narrow-bladed knife transfixes the lip above the apex of the cleft. With a sawing movement the knife is carried down to the red margin of the lip on each side, well away from the red margin of the cleft.

The knife is not made to cut out, but curves slightly inwards at the lower part of the incision on each side. The tissue pared from each side of the cleft is left attached at its lower margins till the exact amount to be removed can be decided on.

The paring must be so carried out that the raw surfaces opposed to one another are as wide as possible. During the paring the coronary artery will be divided, but the bleeding can be controlled by the assistant grasping the lip near the angle of the mouth. The vessel is secured with forceps, which are left

on for some minutes, and then removed; ligatures are seldom necessary.

3. *Closing the Cleft.*—The margins of the cleft are approximated to make sure that enough has been removed and that the lip is sufficiently freed to be sutured together without undue tension.

The sutures are inserted in the following order: A suture is passed through the exact junction of the red and white portions of the lip on each side so as to bring these accurately together. The next suture is passed half-way up the cleft, a third is passed near the apex of the cleft. These three sutures should be passed so as to include everything in their grip, except the mucous membrane on the deep surface of the lip.

Finer sutures are passed uniting the very edges of the cleft between the deep sutures; the edges of all should be left long. On pulling on the end of these sutures the lip can be everted

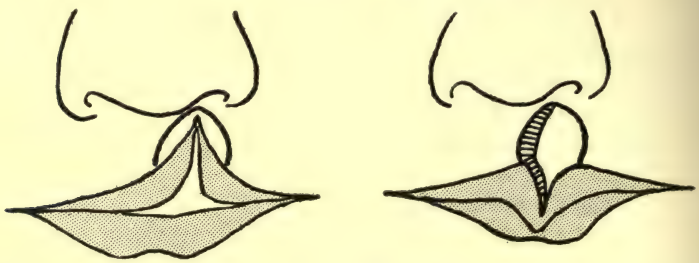


FIG. 163.—INCOMPLETE HARE-LIP.

and sutures passed, uniting the edges of the mucous membrane on its deep surface. The mucous membrane on to the alveolus, divided in the first step of the operation, is sutured in its new position. The ends of all the sutures are then cut short. The tag of tissue which is still attached to the red margin of the lip is cut so that it projects a little way beyond the edge of the lip, to ensure that no notch is left by the subsequent contraction of the scar.

A simple way of uniting the end of the tag is to tie a ligature round it and cut off the portion on the distal side of the ligature.

Hare-lip pins now are never used, but the parts may be kept at rest and tension taken off by applying a butterfly or dumb-bell shaped piece of gauze to the two cheeks, the bridge connecting the two cheek portions lying over the cleft in the lip. The gauze is kept in position with collodion, and should be applied with the cheeks in their natural position, and not pushed forward,

as is sometimes recommended, as this causes discomfort, and the child resents its presence. The shrinkage of the collodion is quite sufficient to take off all tension.

After-treatment.—The wound must be kept clean and nasal discharge not allowed to accumulate on it, no dressing beyond collodion and gauze need be applied. A small dose of opium should be given directly after the operation, and for the first few days chloral may be given to allay any irritation causing the child to suck at the stitches or cry.

In severe cases of hare-lip the breathing of the child should be watched for some hours, as considerable embarrassment is sometimes met with owing to the fact that the cleft, through which the child has been accustomed to breathe, has been obliterated.

If difficulty is met with, a small strip of gauze should be applied with collodion between the lower lip and the chin. As this dries it contracts and pulls down the lower lip slightly, and allows the child to breathe through its mouth. The stitches should not be removed before the eighth day. A fractious child should be placed under an anæsthetic when the stitches are being removed, for fear that during the struggling and crying, which takes place, the edges of the wound may come apart.

Other Methods.

1. *Nelaton's Method.*—This is used for slight notches and shallow clefts. A curved incision is carried round the apex of

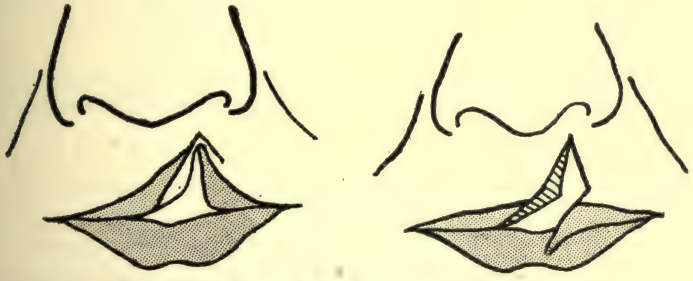


FIG. 164.—HARE-LIP: NELATON'S OPERATION.

the notch, but does not reach the lip margin on either side. The incision is then converted into a lozenge-shaped wound, the margins sewn together so that the notch is replaced by a prominence (*see* Fig. 164).

2. Mr. Goyder's method for slight notches is a more accurate method than the last (Fig. 164).

3. Mr. Goyder's method of dealing with complete hare-lip is also shown (Fig. 166).

Where the cleft runs up into the nose the ala nasi on that side

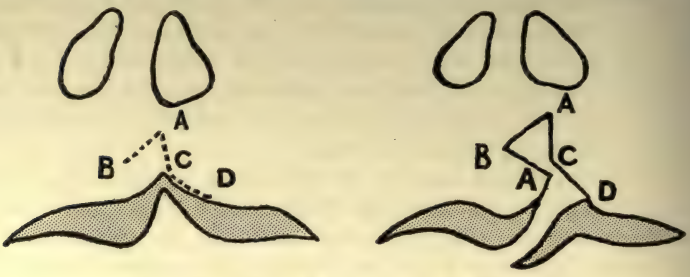


FIG. 165.—HARE-LIP: GOYDER'S METHOD.

is much flattened and splayed outwards. When freeing the lip from the gum the ala must be detached. When the sutures are

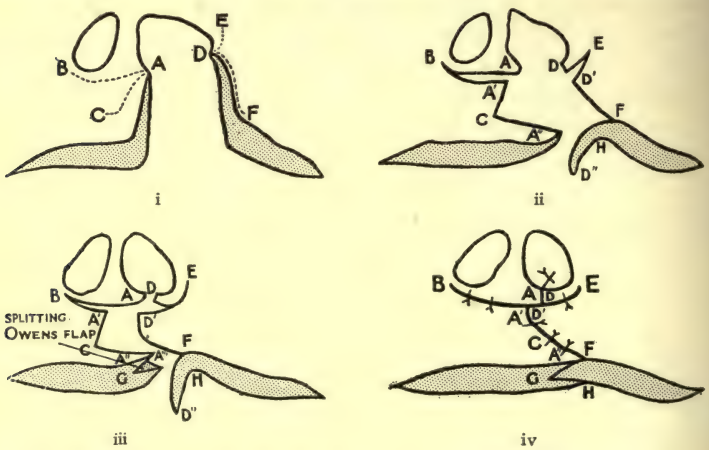


FIG. 166.—COMPLETE HARE-LIP: GOYDER'S OPERATION.

i, Incisions. ii, Suture A–D; BADE to BA'D'E. iii, Split flap C–A''–G; suture A'CA'' to D'F; AG to FD''; and GA''' to D'H. iv, Operation complete.

passed great attention must be paid to the remodelling of this side of the nose.

2. Double Hare-Lip

In favourable cases the operation for double hare-lip is little more difficult than that for the single condition. But when the premaxilla is represented by a rounded knob fixed, it may be,

to the very end of the nose, much difficulty arises, and a favourable result is hard to obtain.

1. *When the Premaxilla is in its Normal Position.*—The steps of the operation are the same as in the case of single hare-lip. The surface of the premaxilla is pared at the sides and below, the margins of the lip are pared on each side of the cleft so as to form a flap. The premaxilla is shorter, as a rule, than the rest of the lip, so the flaps are sutured together below it, and the pared edges to the side of the premaxilla, the resulting scar being Y-shaped.

2. *When the Premaxilla is in Advance of the rest of the Lip.*—Here the premaxilla is attached to the end of the nasal septum, and must be dealt with in one of the following ways.

(1) The bone may be pressed back into position between

FIG. 167.—COMPLETE DOUBLE HARE-LIP.

Removal of a triangular portion of the septum to get the premaxilla back into position.

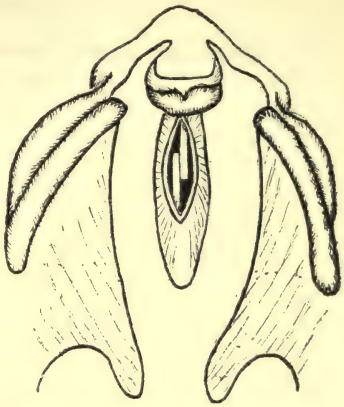


FIG. 168.—DIVISION OF THE SEPTAL CARTILAGE.

The two portions overlapping as the premaxilla is pushed back into place.

the two halves of the cleft palate. This must be done forcibly, so as to fracture the nasal septum, which would otherwise tend to make it reassume its old position. This method has the disadvantage that the bone is merely rotated on itself, and the teeth when they erupt point backwards into the mouth.

(2) If there is not room to press back the premaxilla between the two halves of the palate the gap may be widened with the chisel and knife, and the raw surfaces fixed in apposition with sutures.

(3) An incision may be made along the lower margin of the septum of the nose, and the muco-periosteum and muco-perichondrium separated up. A wedge-shaped piece of cartilage is

then removed from the septum and the premaxilla pressed back and fixed with sutures in its new position without very much rotation. Or a vertical incision may be made in the cartilage, and the anterior part pressed back so as to lie alongside the posterior portion (*see* Figs. 167 and 168).

(4) If none of these methods are followed the mucous membrane over the lower part of the premaxilla can be incised and the interior of the process together with the incisor tooth sacs scooped out. The remainder is used to help to fashion the upper lip (Fergusson).

None of these methods can be considered very satisfactory as regards the appearance of the nose and lip.

CLEFT PALATE

Difficulties of the Operation.—Other conditions being equal, it is much easier to close a narrow than a wide cleft, a partial than a complete cleft, and one which only involves the soft palate than one which extends a long way into the hard palate.

FIG. 169.—U-SHAPED CLEFT.

FIG. 170.—V-SHAPED CLEFT. This is the easier to close.

The shape of the cleft is of some importance, as one in which the margins join in front in a V-shaped manner is easier to close than one in which they join in a U-shaped fashion. In the latter case a small hole is apt to be left unless the rounded angle is very freely pared.

The slope of the palatal processes is important as the flaps come more readily together when freed from a highly arched palate than from one where the palatal processes are nearly horizontal.

It should also be remembered that in complete clefts the two halves of the alveolar margins are often not on the same plane, and are therefore very difficult to join in front.

The treatment of the premaxilla when attached to the tip of the nose has been mentioned when dealing with hare-lip.

Fergusson or Langenbeck's Operation

Instruments.—A fine sharp-pointed knife, a rectangular knife, two pairs of long-handled dissecting forceps with fine teeth, a fine hook, a fine pair of curved scissors, an ordinary pair of scissors, curved raspatories, long-handled cleft palate needle,

either curved or rectangular as preferred, a self-retaining gag, artery forceps, sponge holders, suture material. The suture material chiefly used now is silkworm gut, which has almost completely superseded the use of silver wire. It is just as good, easier to introduce, and less irritating. Horsehair, silk and silver wire may be used.

Position.—This varies with different surgeons. The child is swaddled in a blanket with its arms by its side, and laid at the end of the table, with a sandbag placed under its shoulders. The surgeon may sit at the end of the table, or at the patient's right side, with the assistant and anæsthetist in the positions most convenient. The anæsthetic is administered by means of a Junker's inhaler, through a tube introduced either into the mouth or the nose.

Cleft of the Soft Palate

Operation.—*Paring the cleft.*—The gag is introduced and the tongue transfixed and drawn forwards with a silk suture. One half of the uvula is seized with long forceps, and that side of the soft palate rendered tense. The fine-pointed knife is now entered through the soft palate, just in front of the angle of the cleft, and made to cut backwards towards the forceps, paring that side of the cleft. The opposite side is similarly made tense and pared from before backwards in the same way. The paring should be done evenly and smoothly, the raw surfaces being cut as thick as possible. In this way the tissue from the edge of the cleft is taken away in one strip and there is the certainty that no part is left unpared.

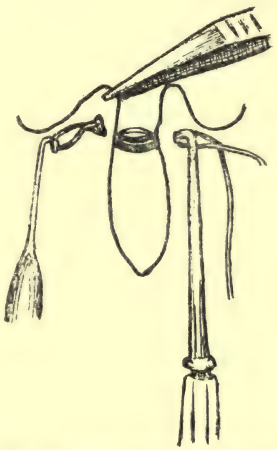


FIG. 171.—METHOD OF PASSING THE SUTURES ACROSS THE CLEFT WITH ONE SWEEP OF A CURVED NEEDLE.

2. *Introduction of the Sutures.*—Sutures of silk-worm gut are passed through both sides of the cleft, which are held steady in turn, they may, in simple cases, be passed with a single sweep of a curved cleft palate needle, which is then withdrawn, leaving the suture in place (Fig. 171). This is the simplest of all methods,

and when feasible is the one to be practised. Other methods are described below.

The sutures are all passed before any are tied, the ends being secured by forceps and allowed to hang from the side of the mouth. When all are in place they are tied in turn, care being taken to prevent the margins of the cleft from being inverted, and to make sure that the raw edges are accurately apposed.

3. *Relieving Tension.*—This has often to be done before the front sutures can be safely tied, and is therefore a movable stage of the operation according to the amount of tension present.

An incision is made through the whole thickness of the soft palate on each side, just internal to the hamular process and extended outwards and backwards into the anterior pillar of the fauces until all tension is relieved.

Any sutures which have not yet been tied are now knotted, and the operation is complete.

Other Methods of Passing the Sutures

1. A long suture may be used, armed with a small curved needle at each end; each needle is made to pierce one side of the soft palate opposite its fellow, and the sutures tied. A needle-holder must be used to pass the small needles.

2. A hook-shaped, long-handled needle is threaded and passed up into the cleft and made to pierce one side of the soft palate from above downwards; the suture is secured and the needle withdrawn. The needle is next turned round and passed through the opposite side of the palate in the same way, and the suture secured. The needle is then withdrawn into the cleft and removed from the mouth.

The two ends of the suture are now tied. These are two very simple methods and are easy to carry out.

3. A slightly curved long-handled needle is passed through one-half of the soft palate and then threaded and withdrawn; it is then disengaged from the suture and made to pierce the opposite side, where it is threaded with the end already lying in the cleft; the needle is then withdrawn and the suture tied. This necessitates threading the needle twice while it is passed through the frail tissues.

4. *The Loop Method.*—With a long-handled needle a loop of silk is passed through one side of the palate and the loop secured as the needle is withdrawn. A single suture is passed through the other side at a point opposite. The single suture is now passed through the loop as it lies in the cleft; the loop is then withdrawn, carrying the single suture with it. The single suture thus traverses both halves of the palate.

5. *The Double Loop Method.*—Instead, as in the last case, of drawing a single suture, a loop of silk may be drawn across the cleft and the ends secured. When a sufficient number of loops are in place, fine silver wire may be hooked on to each, and by drawing on the loop the silver wire is pulled into place. Each piece of silver wire is twisted up and short cut. This method is very seldom used now.

Cleft of the Hard Palate

1. *Paring the Cleft.*—The mouth being gagged open and the tongue drawn forward, the edges of the cleft are pared in exactly the same manner as described in the operation for cleft of the soft palate, the same care being taken to have an even and thick raw edge along the whole extent of the cleft.

2. *Lateral Incisions and Raising the Muco-periosteum.*—Lateral incisions are made down to the bone from just internal to the last molar tooth along the alveolar margin, to just beyond the apex of the cleft. If the cleft extends far forwards the lateral incisions should end just behind the canine teeth on each side, and should not pass further forwards than this for fear of interfering too much with the blood supply. By keeping close to the

FIG. 172.—CLEFT PALATE: THE INCISIONS TO RELIEVE TENSION.

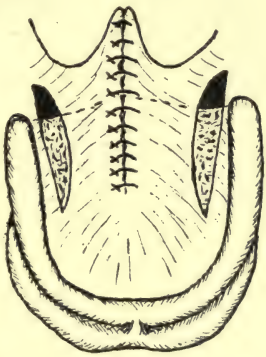


FIG. 173.—CLEFT PALATE: OPERATION COMPLETED.

last molar tooth, the descending palatine artery is kept intact, running in the muco-periosteum which is subsequently to be raised.

Suitable raspatories are now used to raise the muco-periosteum from the hard palate, working from the lateral incision inwards towards the cleft into which the instruments eventually protrude. Care must be taken that the muco-periosteum is freely raised a good distance in front of the apex of the cleft, and as far back as the posterior edge of the hard palate on each side. A curved pair of scissors is now passed into the cleft, one blade being between the raised muco-periosteum and the other in the nasal cavity. By cutting transversely outwards the soft palate

is completely freed from the posterior edge of the hard, and is only attached to the raised muco-periosteum. This must now be repeated on the opposite side. The freeing of the soft palate in this manner is perhaps the most important step in the operation, and allows the two margins to come together without any tension opposite the junction with the hard palate.

3. *Introduction of the Sutures.*—The sutures are now introduced by one of the methods already described, each suture being used to steady the tissue during the passage of the next. When all are in position they are tied, care being taken that in so doing the

FIG. 174.—CLEFT PALATE: SEPARATING THE UPPER HALF OF THE SOFT PALATE FROM THE BACK OF THE HARD.

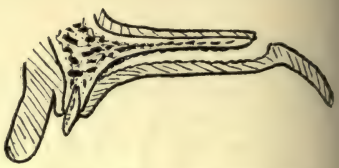


FIG. 175.—CLEFT PALATE: SEPARATION COMPLETE.

raw surfaces come into accurate apposition. Any tension that may remain is relieved by carrying the lateral incisions a little outwards and backwards into the anterior pillars of the fauces.

Fergusson's method for wide and complete clefts is to pare the edges as usual and then to make the lateral incisions down to the bone on each side. The bony palate was then divided with a chisel, and the mesial portions prized inwards. The edges of the cleft are united with sutures and the bones prevented from separating by wire sutures passed round through the lateral incisions. This method is now seldom performed.

The Flap Operation

This was first devised by Davies-Colley, and has since been perfected by Mr. Arbuthnot Lane, who closes the cleft in both hard and soft palates by this method. Lane's needle-holder and special curved needles are necessary. The method is particularly adapted to wide clefts where the palate is much deformed. The flaps are obtained from the muco-periosteum of

the hard palate on either side of the cleft. In young infants before the teeth have erupted, the gum of the upper jaw may be encroached on if a large flap is needed. This is the chief reason for operating at an early age.

Operation.—The mouth is gagged open and the tongue transfixed with a silk suture, which is held by an assistant.

1. *The Flaps.*—With the surgeon sitting at the head of the table it is more convenient to raise the large flap from the right side, and turn it over to suture it underneath the smaller one raised from the left side. The incision starts from the apex of the cleft and passes forwards and outwards to the right in a curved manner till it reaches the alveolar margin. From here it passes along the alveolar margin to the posterior edge of the hard palate.

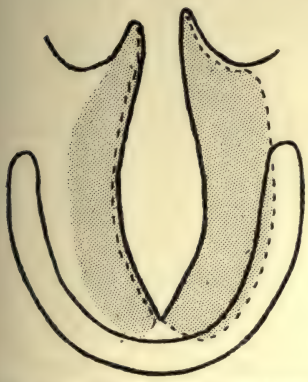


FIG. 176.—THE FLAP OPERATION.

The dotted line marks the incisions for the flaps, the area from which they are raised is dotted.

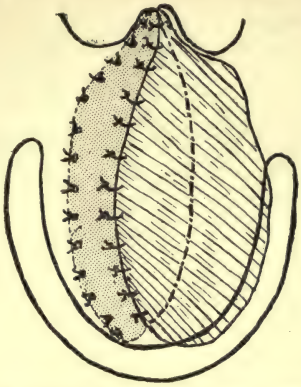


FIG. 177.—THE FLAP OPERATION.

The right flap turned over and stitched under the left. The dotted area where they overlap, the shaded area the raw surface which remains.

The right half of the uvula is steadied with forceps as the incision is carried backwards across the soft palate and along the posterior edge of the soft palate. The incision passes down to the bone as far as the hard palate extends, behind this point only the mucous membrane must be divided. The muco-periosteum is raised from the bone with fine curved elevators, care being taken not to drive these through the flap as the margin of the cleft is approached. At the posterior edge of the hard palate the descending palatine vessels will be met with, they are easily seen and are clamped with a strong pair of forceps before they are divided. The soft palate is split with a sharp-pointed pair of scissors, which cut only in small snips for fear of cutting right through the velum.

The opposite (left) half of the uvula is now seized and drawn tense. With a sharp-pointed knife the mucous membrane of the uvula is incised on its inner surface, and the knife carried along the edge to the anterior end of the cleft. With a periosteal elevator the muco-periosteum is raised from the bone from the cleft outwards, the soft palate on this side being split by scissors.

The splitting of the soft palate is perhaps the most difficult to accomplish, as the thick mucous membrane should be raised from off the muscles without piercing the latter or button-holing the former.

FIG. 178.—PALATINE PROCESSES SHOWING CLEFT.

FIG. 179.—THE FLAPS DISSECTED FROM THE PALATINE PROCESSES.

FIG. 180.—THE FLAPS FOLDED OVER AND SUTURED IN POSITION, SO THAT THE RAW SURFACES (SERRATED) ARE IN APPOSITION.

2. *The Sutures.*—First row, long silk or silk-worm gut sutures are used with very small curved needles at each end. The large flap (right side) is folded over so that its raw surface is exposed, it is then pierced from the mucous to the raw surface with both the needles close to one another. Each needle is then made to pass between the left flap and the bone, and made to pierce the left flap from the raw to the mucous surface about half an inch from the margin of the cleft. On pulling on the two ends of the suture the right flap will pass under the left, the two raw surfaces being in apposition. All the first row of sutures is passed in this manner from before backwards, the ends being secured with artery forceps and not tied till all are in position. When all have been inserted they are tied and cut short. The second row of sutures is passed through the raw surface of the right-hand flap and the free edges of the left-hand flap. They are passed with a single sweep of the needle, and are tied as soon as passed. The sutures are inserted from before backwards and placed close together.

By this means two broad raw surfaces are held in contact with one another. A large raw area is left exposed in the mouth; this heals in two to three weeks, according to its size.

Brophy's Operation

This is best performed on children under three months, but can be carried out in children up to but not beyond six months old. Two special-handled needles are required.

Operation.—1. The cleft is pared as in Langenbeck's operation.

2. *Passage of the Wire Sutures.*—The cheek is raised and a Brophy's needle threaded with strong silk is passed through the right superior maxilla from without inwards just behind the malar process and high enough up to be above the level of the palate. The loop of silk is caught in the cleft and the needle withdrawn. A needle, threaded in the same way, is passed through the left superior maxilla at a point exactly opposite. The loop is secured and the needle withdrawn. The second loop is threaded through the first, which is then withdrawn, pulling the second loop through both maxillæ and, if necessary, through the septum. By means of this loop a stout piece of silver wire is carried across through both maxillæ. In the same way one or sometimes two similar pieces of silver wire are passed through the anterior parts of the bones above the level of the palate.

3. *Fixing the Lead Plates.*—The ends of the pieces of silver wire are passed through holes in narrow lead plates moulded to fit the outer surfaces of the maxillæ, one on each side. The ends of the wires are then twisted together on each side, while with the thumbs the two bones are pressed forcibly inwards until the cleft is completely closed. The wires are twisted up to fix the bones in their new position.

4. *Suturing the cleft.*—The pared edges of the cleft are sutured together, special care being taken with the edges of the soft palate.

If, owing to the ossification of the bones, it is found that compression with the thumbs is not sufficient to obliterate the cleft, a small incision is made above the alveolar margin below the malar bone. Through this the superior maxilla is partially divided by means of a chisel parallel to the alveolar margin. This is repeated on the opposite side until the cleft can be obliterated.

The lead plates and wire sutures are not disturbed till two to four weeks have elapsed after the operation. During this

time the mouth and nose are kept as clean as possible. If hare-lip is present at the same time, Brophy, together with most other surgeons, closes the palate completely before operating on the lip.

Dangers and Causes of Failure of Cleft Palate Operations

After-treatment.—The child should be kept as quiet as possible, small doses of opium or syrup of chloral combined with potassium bromide being administered for the first two days. The food will to some extent depend on the age of the child, only fluids must be allowed. Milk and water, milk, or soup being given. All food must be given by means of a spoon, no bottle or teat is permissible, and if possible the fluids should be first sterilized. The mouth and nose should be kept as clean as possible. The nose may be syringed with weak boracic, the child being held face downwards over a basin so that the fluid runs out of the mouth. If this upsets the child and makes it cry too much it must be discontinued. No attempts must be made to clean the suture line with swabs. The arms of the child should have light cardboard splints round the elbows to prevent the fingers being put in the mouth. If the stitches are cut short there is less likelihood of the tongue being worked against the suture line. The sutures should not be removed before the fourteenth day, and if not cutting out should be left in longer. When the child reaches the talking age great care must be expended in teaching it to articulate distinctly. If it has already learnt to talk, the teaching is the harder in that the child has to unlearn a great many bad habits of speech. All explosives and aspirates must be constantly practised till a good control is gained over the movements of the soft palate. Distinct articulation is the criterion of the success or failure of the operation.

Hæmorrhage.—This may occur at the time of the operation or supervene as secondary hæmorrhage some days later. If severe, it is usually the descending palatine which is bleeding and the posterior palatine canal may have to be plugged. There is often a general oozing from the raw surfaces for the first twenty-four hours after the operation, during which time a small baby may lose a serious quantity of blood. Douching out the mouth and nose with a solution of adrenalin, 1 in 3000, will always arrest this.

Pyæmia and Septicimæa.—The danger of sepsis is always at hand in dealing with an infected cavity such as this, but can

be greatly reduced by attention to the cleanliness of the mouth.

Diarrhœa.—This is a great danger and a common cause of failure of the operation, should it come on severely, even fourteen days after the operation ; the newly formed scar tissue uniting the edges of the wound simply melts away and the condition is worse than before the operation. Children with cleft palate are always liable to diarrhœa, but particularly so after their operations.

The anæsthetic upsets the digestion for a day or more, and the diarrhœa may start at once, later it is probably caused by the organisms from the granulating surfaces infecting the whole intestinal tract. If diarrhœa starts milk should at once be stopped and albumin water substituted, castor oil (min. v. for a small baby) given three times a day to clear out any irritating material likely to keep up the diarrhœa. Intestinal antiseptics may be tried, but no great reliance can be placed on them. If all goes well, by the third or fourth day whey may be added to the albumin water, later raw meat juice or sterilized milk tried. Milk so easily decomposes and turns sour that it is important to stop it at the first sign of diarrhœa.

Among other causes of failure are, imperfect paring and faulty stitching of the edges of the cleft, imperfect relief of tension, solid food, sucking the fingers, frequent examination, and the formation of scar tissue from previous operations.

The above dangers refer to operations performed in infancy, where the mortality is very high, 11 to 15 per cent. according to the age. In children above five years the mortality is practically nil.

PLASTIC OPERATIONS

With the methods now at hand for the grafting and transplantation of skin many of the plastic methods for covering in raw areas are no longer needed, but there remain many simple methods of covering in raw surfaces which should be kept in mind.

In all plastic operations the end aimed at is the rapid and sound healing of the raw edges of skin which are brought in apposition with one another, so that the breach of continuity, whatever its nature, shall be remedied with the smallest amount of scar tissue. The several factors which must be taken into consideration to attain this satisfactory result are as follows :—

1. *Asepsis.*—This must be rigidly enforced, and is essential if a small scar is to result. It must be borne in mind that if sepsis occur and the flaps break down a state far worse than the original condition may be the result of the operation, perhaps precluding all hope of a future interference, by the amount of scar tissue formed.

2. *General Health.*—The general health and recuperative power of the patient must be taken into account, and means pursued to render these as satisfactory as possible. Puny infants and decrepit old people are bad subjects for plastic operations.

3. *The Flaps.*—These, if small, contain the skin and superficial fat from off the deep fascia, if large the deep fascia should be raised with the flap.

While the flaps are being dissected up the knife is kept directed towards the deeper parts so as to avoid scoring the superficial fatty tissue under the skin in which the blood vessels run. Allowance must be made for the contraction which takes place as soon as the skin is dissected up. The edges must be fresh cut and as thick as possible where they are stitched in apposition. No undue tension should be caused by the stitches.

4. *Good Vascular Supply.*—The vascular supply of the region should be taken into account when cutting the flap. In the limbs the vessels run down in the fatty tissue under the skin, the base of any large flap should therefore be at the upper end.

Scar tissue is badly supplied with blood and should never be used as a flap. If too much tension is put on the flap the vascular supply is seriously interfered with, and sloughing of the edges is apt to occur.

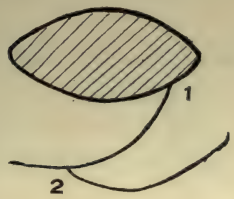
Methods.—The following simple methods may be taken as the groundwork on which the more complicated plastic operations are evolved.

Closing an Elliptical Raw Surface

1. The simplest method to close a small raw surface of this shape is to under-cut the edges opposite the wider portions of the gap and to slide the edges inwards, as in Fig. 181.

2. If the area is larger, flaps may be cut after Weber's method (*see* Fig. 182). The flaps are dissected up and stitched, the numbers denoting the positions of the various parts of the flaps before and after the operation. Similar flaps may be cut, one on each side of the raw surface.

FIG. 181.



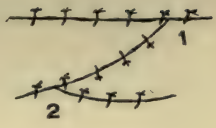


FIG. 182.

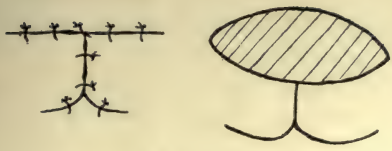
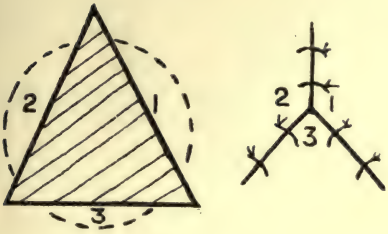


FIG. 183.



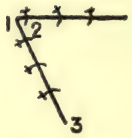


FIG. 184.

FIG. 185.

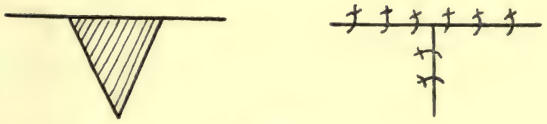


FIG. 186.

FIG. 187.

FIGS. 181–187.—PLASTIC OPERATIONS.

Closing a Triangular Raw Surface

1. If the area be small and equilateral it may be closed by suturing together the angles of the wound so as to form a tri-radiate scar, each side of the triangle being freed for a short distance (Fig. 184).

2. If the area is larger the base of the triangle may be produced on one side, the skin dissected up until it can be slid across to the opposite side (Fig. 185). If of still larger size the base of the triangle may be produced in both directions and both sides dissected up (Fig. 186), a T-shaped scar being left.

3. Jaesche's method is to produce the line of the base of the triangle in a curved manner and slide in the area dissected up as in Fig. 187.

4. Dieffenbach's method is to produce the line of the base and then make a second incision parallel with the side of the triangle to be closed. The whole area is dissected up and slid inwards so as to cover the raw surface. A smaller triangular raw surface is left, which can be grafted (Fig. 188).

5. If the area is an obtuse-angled triangle the sides bounding the obtuse angle are produced a short distance, the two sides of the triangle are then dissected up and sutured to the base (Fig. 189).

Closing a Quadrilateral Raw Surface

1. If the area is small the shorter sides of the gap are produced on one side and the flap dissected up and slid inwards to the opposite margin (Fig. 190).

2. If the area is larger this procedure is carried out on both sides, the longest margins of the wound being slid towards each other and sutured (Fig. 191).

3. Brun's method of closing an irregular quadrilateral raw area is shown in Fig. 192.

4. Langenbeck's method of closing an irregular quadrilateral area is shown in Fig. 193.

SKIN GRAFTING

Skin grafting is used to cover over raw surfaces which may have resulted from previous operative procedure or may be produced by chronic ulceration.

FIG. 189.

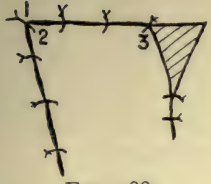


FIG. 188.

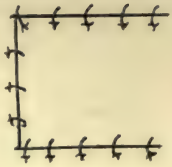


FIG. 190.

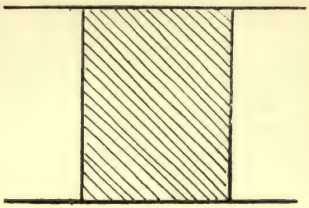
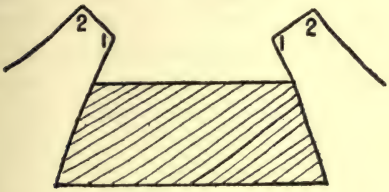


FIG. 191.



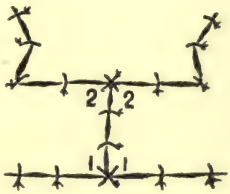
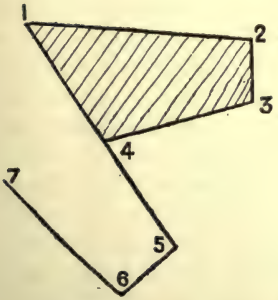


FIG. 192.



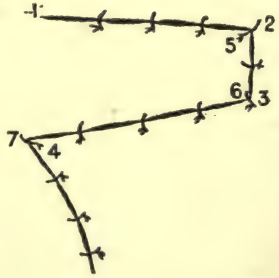


FIG. 193.

FIGS. 188–193.—PLASTIC OPERATIONS.

The following conditions are essential to the success of the operation.

1. The area grafted must be aseptic.
2. The area from which the grafts are taken must be aseptic.
3. The life of the grafts must not be endangered by the use of any strong antiseptic solutions.
4. The grafts must not be displaced by the subsequent moving or changing of the dressings.

Thiersch's Method

The area from which the grafts are to be taken, usually the upper arm or thigh, is shaved and carefully disinfected.

If the area to be grafted is a freshly made wound it should already be aseptic. If an old standing ulcer is to be grafted, it should be disinfected with pure carbolic two or three days previously, the skin around shaved and the surface dressed daily with an antiseptic dressing so that it shall be clean at the time of operation.

Operation.—The patient being anæsthetized the surface to be grafted is denuded of all granulations by scraping with a sharp spoon and the edge of the ulcer removed. The surface is then washed with carbolic lotion which is in turn removed by washing with normal saline. A layer of protective is now applied to the raw surface and firm pressure made over it by the assistant.

The surface from which the grafts are to be obtained is now exposed and the skin put on the stretch. With a sharp heavy razor the grafts are now cut as wide as possible and of the required length. The razor is moved with a fine sawing motion and must be kept wet or the grafts will become detached before they are long enough.

The line of section should pass through the upper parts of the skin papillæ so that the grafts consist of the horny and the upper part of the Malpighian layers. The grafts are cut one after the other till sufficient are obtained to cover in the raw area. Each graft may be transferred at once to the surface to be grafted if the bleeding from this has ceased, or if not may be laid aside in warm normal saline solution. The grafts are then spread out on the area to be grafted and all wrinkles smoothed out. The grafts should be so arranged that they overlap the edges of the wound and overlap each other. All bubbles are carefully smoothed away from under the grafts. Strips of protective are now laid over the grafts so as to cover them completely and prevent them becoming adherent to the dressing,

which should not be disturbed for four days. The dressings may then be changed and fresh protective applied.

At the end of a week those grafts which are living will be pink and quite adherent, while those which have died will be white and loose. The area from which the grafts have been taken is dressed with protective and gauze and need not be touched for a week or ten days, when it will be found to be completely healed.

Reverdin's Method

Less satisfactory, as it has not such a wide range of application, is Reverdin's method. The preparations are the same as in the last with the exception that the granulations are not scraped off from the area to be grafted. Small pieces of epidermis about the size of a hemp seed are snipped off with curved scissors and planted close together on the granulations. These grafts consist, as in Thiersch's method, of the horny layer with the superficial part of the Malpighian layer of the skin so that a drop of blood slowly oozes out after each snip. When sufficient have been planted protective is laid over the top and a dressing applied. At the end of four days the dressing is changed with great gentleness, when all the grafts will have disappeared. In another four days a film-like ring, consisting of growing epithelium, will be seen round the place where each was planted. These areas rapidly coalesce and thus cover in the raw surface. They should be placed close together, as each one will only cover an area about the size of a sixpence and then ceases to grow. The scar is more apt to break down than that formed by Thiersch grafts.

Croft's Method

This method of grafting by means of granulating flaps is more tedious than the two preceding and chiefly suitable for grafting the wound left after dividing the contracted scar of a burn.

Where the wound to be grafted is large the graft has to be a suitable size—eight or nine inches in length and three inches wide. The skin is carefully prepared at a place where it can be turned in to fill up the gap left by dividing the cicatrix. Two parallel incisions are made down to the deep fascia marking out a broad strap-like area of skin which is now dissected up off the deep fascia as thickly as possible.

Pieces of sterilized green protective are now placed between the graft and the bed from which it has been raised, and this

with occasional renewals is kept in place for two to three weeks. At the end of this time the under-surface has become covered with granulation tissue, the width has diminished while the thickness has increased. The scar is now freely divided and one end of the graft is cut so that it can be laid across the new raw surface and stitched in position without tension.

It is best to insert stitches at the sides as well as the ends, as the latter is the part most apt to slough. When this happens the graft will begin to contract and retract unless fixed. As time goes on the graft flattens out and becomes perhaps twice as wide as it was originally. This form of grafting takes a long time, as nine to twelve months may be needed to bring about a successful result.

CHAPTER XIII

Operations on Tendons

The surgical proceeding of dividing a tendon is known as tenotomy. There are two methods by which this operation is carried out. In the first, the operation is performed by the sub-cutaneous, in the second, by the open method.

1. The Sub-cutaneous Method.—By this method the tendon is divided through a very small skin incision, the knife being guided by the sense of touch and resistance. The advantages of this method are (1) the small amount of scarring which results from such a small wound; (2) the small risk of sepsis. Before the advent of aseptic methods this latter argument was all important, now it can scarcely be raised. The same cleanliness, it is hardly necessary to add, must be observed with a small as with a large wound. The disadvantages of the method are that the surgeon is working in the dark, not able to see what he is doing, and liable to wound important structures in the neighbourhood. This danger is the more real when it is remembered that the operation is often performed, firstly, in deformities, where the normal relationships of the structures are disturbed; and secondly, in young and fat infants, where the structures are difficult to make out.

2. The Open Method.—By this method an incision is made large enough to enable the surgeon to see exactly what he is doing, and to make sure that he is only dividing the necessary structures. The disadvantage is that the scar may be unsightly. This can only be urged in a very limited number of operations. The other argument that sepsis is more likely to occur in a larger wound than in a smaller one is little more than theoretical, considering that the size of the wound necessary in nearly all cases is rarely more than one to two inches in length.

Instruments and the Method of Operating.—When the sub-cutaneous method is employed, special knives, called tenotomes, are used. These are knives with very narrow blades set on a

narrow blunt shank. The knives are of two kinds, one sharp, and the other blunt-pointed. The tendon to be divided can usually be made to stand out prominently, and a point should, if possible, be selected where there is no synovial sheath. The sharp-pointed tenotome is taken and held in the hand in the same way as a pen, the knife is pushed through the skin by the side of the tendon, the blade being on the flat as regards the structure to be divided. The blade is made to pass under the tendon, which is now slightly relaxed, and moved up and down, so as to divide the tissues sufficiently to allow of the insertion of the blunt-pointed tenotome. When this has been done the knife is withdrawn. The blunt-pointed instrument is now inserted into the small wound, the blade being "on the flat." When fully introduced the blade is turned at right angles to the tendon, which at the same time is rendered tense, and with a sawing movement this is divided, the forefinger of the left hand being placed over the point of section to prevent the skin being cut when, as usually happens, the tendon suddenly gives way with a snap. Care should be taken that the last fibres of the tendon are really divided.

After-treatment.—The wound itself can be sealed at once with a collodion dressing. There are three ways of treating the severed tendon—the slow, the rapid, and the immediate. In the slow way the two ends of the tendon are left in contact for several days till union has taken place, then the uniting material is slowly stretched to the required amount, several weeks being taken before the required position is attained. In the rapid way there is a slight interval left between the two ends of the severed tendon, the limb being fixed firmly in this position for a week, at the end of which time the position is changed, a greater interval of separation being left between the two ends, and the limb fixed in this position. In two or perhaps three such fixations the limb should be in the position required. In the immediate method the limb is at once fixed in the required position it is afterwards to retain, and the gap separating the ends of the tendon allowed to fill up with newly-formed tissue.

The rapid and the immediate methods are the ones mostly employed owing to the amount of time saved and the fact that considerable pain is sometimes felt in stretching the new tissue. The danger of the newly formed tendon stretching if the immediate method is adopted is only theoretical, the trouble always is its contraction.

Tenotomy of the Sterno-Mastoid.

This operation is called for in certain cases of wry-neck.

Anatomy.—The muscle is usually divided a quarter to a third of an inch above its origin. The muscle here is in two portions, a muscular part attached to the upper surface of the inner end of the clavicle, and a tendinous part attached to the upper and front part of the sternum. The muscle lies in a strong sheath of deep cervical fascia. This is better marked on the deep than on the superficial surface, and needs dividing with the muscle. Along the anterior border of the sternal head is the anterior jugular vein, which just above the sternum pierces the deep fascia and turns outwards behind both heads of the sterno-mastoid to open into the external jugular vein. At the outer border of the clavicular head at this level is the external jugular vein which pierces the deep fascia a short distance above the clavicle. Behind the muscle lie the contents of the carotid sheath, with only the thin layer of muscle formed by the sterno-hyoid and sterno-thyroid muscles to separate the two structures. Considering the importance of the structures in the neighbourhood, and the risk they run of being injured when working in the dark by the sub-cutaneous operation, it is no wonder that this method has fallen into disrepute.

Position.—The patient lies in the dorsal position, a sandbag is placed under the shoulders so that the head can be fully extended. An assistant stands so as to be able to manipulate the head.

Operation.—A one-inch incision is made transversely immediately above the inner end of the clavicle. The skin is very movable in this region, so that the wound can be retracted inwards to expose the sternal attachment, and then outwards to expose the clavicular attachment. The tendinous sternal insertion is divided first, the assistant putting this portion well on the stretch. The wound is then retracted outwards and the muscular clavicular attachment divided. Both portions should be divided from before backwards close to the bone; if this latter precaution is taken there is no bleeding. The dense fascia on the deep surface of the muscle must always be divided. The head should be manipulated in all directions and any tense bands divided. If the anterior or external jugular veins are seen they should be drawn aside. The skin incision is then drawn together with a fine subcutaneous suture.

After-Treatment.—If everything has been divided in this way,

there is very little likelihood of recurrence. The head should be fixed in the torticollis position of the opposite side, by incorporating some plaster of Paris in the bandages, which should go round the chest, neck and head. A week or ten days is the longest that this need be worn, after which no apparatus should be applied, but systematic exercises should be prescribed and carried out.

Tibialis Anticus

Tenotomy of this tendon, as well as the others about the region of the foot, is usually called for in cases of talipes varus and equino-varus, to enable the foot to be manipulated into proper position.

Anatomy.—This tendon is the innermost of those situated in front of the ankle-joint. As it passes under the two parts of the anterior annular ligament the tendon is surrounded by a synovial sheath, which reaches from about one inch above the level of the ankle-joint to within one inch of the insertion of the tendon into the inner surface of the internal cuneiform and base of the first metatarsal bones. The tendon is most usually divided between the bony attachment and the lower level of the synovial sheath, *i.e.* within an inch of its termination. At this point the tendon rests on the scaphoid, above the tubercle of which it can be felt on manipulating the foot. To the outer side of the tendon lies the dorsalis pedis artery with the tendon of the extensor proprius hallucis separating the two.

Position.—The patient lies in the dorsal position with the foot over the end of the table, the limb lying on the outer side. The surgeon stands on the outer side of the limb, with the assistant opposite him. The assistant steadies the leg with one hand while with the other he manipulates the foot.

Operation.—The tendon is rendered prominent by the assistant attempting to evert the foot. A sharp-pointed tenotome is inserted on the outer side of the tendon just in front of the tubercle of the scaphoid. The tendon is then relaxed and the knife passed inwards under it till the point is felt beneath the skin on the inner side. The blade, which is kept parallel to the tendon, is moved backwards and forwards slightly to make a track for the blunt-pointed instrument, and then withdrawn. The blunt-pointed tenotome is now introduced along this track until the end is felt under the skin on the inner side of the tendon. The left fore-finger of the surgeon is kept on the skin over the region while the blade of the knife is turned at right angles to the tendon, which is now rendered tense. With a sawing movement the tendon is severed.

The Tibialis Posticus

Anatomy.—The tibialis posticus muscle gives rise to its tendon about one inch above the level of the ankle-joint. The tendon lies in the innermost compartment under the internal annular ligament in a groove on the back of the tibia. The synovial compartment only extends upwards about one inch above the tip of the internal malleolus. The tendon is usually divided above the level of this synovial sheath, *i.e.* about the level of the base of the malleolus. To the outer side of the tendon in a separate synovial sheath lies the tendon of the flexor longus digitorum. Further out still are the posterior tibial vessels and nerve.

Position.—As in the last operation.

Operation.—The assistant extends the foot so as to relax the tendon. The sharp-pointed tenotome is inserted just above the junction of the internal malleolus with the shaft of the tibia. The blade is passed, on the flat, between the tendon and the bone ; it is moved up and down to form a track for the next instrument and then withdrawn. The blunt-pointed tenotome is then pushed along this track, the left forefinger of the surgeon being placed over the tendon. The blade is then turned backwards towards the tendon, which is now rendered tense by the assistant flexing and everting the foot. The tendon is divided by cutting backwards on the finger. The knife should not be passed too deeply, as otherwise the tendon of the flexor longus digitorum, or even the posterior tibial vessels, may be divided. Should the latter accident occur, firm pressure must at once be applied to control the hæmorrhage. This is usually quite sufficient.

Tendo-Achillis

Anatomy.—This powerful tendon is the means of insertion of the gastronemius and soleus muscles into the os calcis. It is usually divided half an inch in the infant and one and a half inches in the adult above its insertion ; this being the narrowest part of the tendon. At this point the various tendons and vessels in relation to the two malleoli are a considerable way from the tendon, and run no risk of injury. The external saphenous vein and nerve are slightly anterior to the tendon on the outer side of the limb.

Position.—As in the preceding operations.

Operation.—The tendon is made to stand out by flexing the

foot slightly. The knife is entered at the inner border of the tendon, which is then relaxed, and the blade passed on the flat in front of the tendon till its point is just felt at the outer margin. A track is made and the blunt-pointed instrument introduced. The blade of the knife is now turned towards the tendon, which is divided from before backwards. During the actual division the assistant forcibly flexes the foot so as to render the tendon as tense as possible. As usual the left forefinger of the surgeon is placed over the skin. Care must be taken that, as the last fibres of the tendon part with a snap, the blade suddenly liberated does not cut out through the skin.

Tendons of the Peroneus Longus and Brevis

Anatomy.—These two tendons are divided about an inch and a half above the tip of the external malleolus. In this position the two tendons lie close together, the brevis being in front of the longus. Behind the external malleolus the two tendons are contained in a common synovial sheath, which lies in a groove on the back of the fibula. This synovial sheath does not extend up more than an inch above the tip of the malleolus, so is not implicated in the operation. Below the malleolus the tendons diverge, and are separated by the peroneal tubercle on the outer surface of the os calcis, the brevis being above and the longus below the tubercle. Here they have separate synovial sheaths. The external saphenous vein and nerve are situated posterior to the tendons behind the malleolus, but on the outer surface of the os calcis these structures cross the tendons superficially.

Position.—The patient lies with the leg rotated inwards resting on a sandbag and projecting beyond the edge of the table, the foot being flexed and inverted. The surgeon stands behind the limb with the assistant opposite him steadying the foot and leg.

Operation.—The sharp-pointed tenotome is inserted at the posterior border of the bone, one and a half inches above the tip of the external malleolus, keeping as close to the bone as possible, so as to pass the blade between it and the tendons. A track is made; the knife is now withdrawn, and the blunt-pointed instrument substituted. While the knife is being inserted it is well to keep the tendons relaxed. The blade of the knife is then turned backwards towards the tendons, which are rendered tense by forcibly inverting and dorsi-flexing the foot. The tendons are divided by slight sawing movements, the skin being protected by the left forefinger.

Tendon of the Extensor Proprius Hallucis

Anatomy.—This tendon lies in a separate synovial compartment in the lower portion of the anterior annular ligament, between the tendon of the tibialis anticus internally and the dorsalis pedis vessels externally. These latter separate the tendon from the compartment containing the tendons of the extensor longus digitorum and the peroneus tertius muscles, which lie still more externally. The tendon is usually divided on a level with the tubercle of the scaphoid, below the termination of the synovial sheath.

Operation.—The foot is extended and the big toe flexed to render the tendon prominent. The sharp-pointed tenotome is inserted immediately on the outer side of the tendon, the handle of the knife being held vertically. The tendon is then relaxed. and the knife blade passed inwards underneath the tendon, the handle being depressed outwards. When a track has been made the blunt-pointed instrument is substituted and the tendon again rendered tense. The blade is then turned upwards and the tendon cut through, the skin being guarded in the usual way with the finger. In this operation the knife is inserted and the tendon divided away from the dorsalis pedis vessels.

Tendons of the Extensor Longus Digitorum and Peroneus Tertius

Anatomy.—These two tendons are contained in one sheath in the lower part of the anterior annular ligament. They may be divided either above or below the level of the ankle-joint. To the inner side at the level of the ankle-joint the tendon of the extensor proprius hallucis lies in front of the anterior tibial vessels. Below this the vessels lie to the outer side of that tendon.

Position.—The patient lies in the dorsal position as before, but the surgeon stands on the inner side of the limb.

Operation.—A point is chosen either opposite the ankle-joint or about an inch below, and the sharp-pointed instrument entered on the inner side of the tendons. The pulsation of the artery should be made out previously and the vessel guarded with the finger nail. The blade is kept close under the tendons while the track is being made. The blunt-pointed instrument is inserted and the blade turned towards the tendons, which are then divided.

Plantar Fascia

Anatomy.—The central portion of the plantar fascia, which is the part chiefly at fault, is attached posteriorly to the internal tubercle on the under surface of the os calcis, while anteriorly it sends four processes to the roots of the four outer toes. Underneath the central portion of the fascia lies the flexor brevis digitorum muscle; on either side of this muscle an intermuscular septum is sent into the deeper parts of the sole from the fascia.

Division of this central portion is indicated in some forms of club-foot. The fascia is in close relation to the skin of the sole, and requires dividing at several points.

Position.—The patient is placed in the dorsal position, with the leg resting on a sandbag. The surgeon stands on the outer side of the limb, with the assistant opposite him steadying the foot.

Operation.—A fine-bladed, sharp-pointed tenotome is inserted a short distance in front of the posterior attachment of the fascia. The blade is guided between the skin and the fascia for a sufficient distance and then the edge turned towards the deeper parts of the sole, the fascia being divided as the knife is withdrawn. The depth to which the knife passes will vary with the thickness of the fascia. While the division actually takes place the assistant makes the structures as tense as possible. Several such divisions will be necessary along the course of the fascia, points being chosen where the skin is not too firmly bound down.

The Tendons of the Hamstring Muscles

Anatomy.—These tendons are divided in the region of the knee just before their insertion. The tendon of the biceps is divided about an inch above its insertion into the head of the fibula. In this position the external popliteal nerve lies behind and slightly to the inner side of the tendon, and can be felt in the living subject. In cases where the tendon is tense and needs division the nerve is further away than usual, but other bands of tissue may be felt and mistaken for the tendon; especially is the posterior part of the ilio-tibial band liable to be so mistaken.

The tendons of the semi-membranosus and semi-tendinosus lie on the inner side of the popliteal space, the former lying to the outer side of the latter. These tendons may both be divided opposite the point selected for the division of the biceps tendon. At this level the internal popliteal nerve and the popliteal vessels are well to the outer side, running down the middle of the popliteal space. Lying deeply on the bone just above the external condyle is the superior external articular artery.

The Biceps Femoris

Position.—The patient lies rolled over on the sound side, the knee is usually flexed. The surgeon stands on the sound side facing the patient.

Operation.—The tendon is made to stand out prominently and the sharp-pointed tenotome passed through the skin immediately to the inner side of the tendon. The blunt-pointed instrument is then introduced along the track, keeping close to the tendon, which is now relaxed. The handle of the knife is next depressed as the blade is made to pass outwards underneath the tendon. The tendon is made tense again as the blade is turned towards the skin and the tendon divided. If possible the nerve should be separated from the tendon with the thumb nail. It is sometimes impossible to feel the nerve when the knee is badly bent. If any doubt exists as to the relation of the nerve, it is better to perform the operation by the open method. A small incision being made along the line of the tendon, which is then cleared, hooked up into the wound, and divided in full view.

The Semi-Membranosus and Semi-Tendinosus

Position.—The patient lies in almost the same position as in the last operation, but rolled more over on the face. The surgeon stands as before.

Operation.—The sharp-pointed tenotome is inserted to the outer side of the tendons, rendered tense by the assistant. They are then relaxed as the knife is passed inwards under both the structures. The blunt-pointed tenotome is now substituted and introduced along the same track. The tendons are rendered tense as the edge of the knife is turned against them and made to cut towards the skin, which is guarded in the usual way with the finger. Care should be taken not to pass the knife too deeply, as the superior internal articular artery may be divided.

The Adductor Longus

This tendon is divided just below its origin from the front of the body of the pubis immediately below the crest. The only structure which might be injured in this position is the deep external pudic artery, a small vessel of no great importance.

Position.—The patient lies in the dorsal position, the thigh, owing to the contraction of the muscle, is flexed and adducted. The surgeon stands on the affected side.

Operation.—The tendon is put on the stretch, and the sharp-pointed tenotome entered on the flat to the outer side of the tendon about half an inch from its origin. The tendon is then relaxed as the blade is passed inwards and downwards beneath it. The blunt-pointed instrument is inserted in the same way on the flat, the blade then turned towards the tendon, which is made tense. The knife severs the tendon, cutting towards the skin, which is guarded with the finger.

Dupuytren's Contraction of the Palmar Fascia

Anatomy.—The palmar fascia consists of three parts, a central and two lateral. The two lateral portions cover the thenar and hypo-thenar eminences, and are of small importance. The central portion is strong and dense, and spreads over the middle of the palm of the hand. In shape this portion of the fascia is triangular with its narrow portion above continuous with the lower border of the anterior annular ligament, where it receives the insertion of the palmaris longus muscle. Below the fascia spreads out and divides into four processes which go to the inner four digits. Between these processes the digital vessels and nerves pass to the sides of the fingers. Each process as it approaches the root of its digit divides into two parts, which arch over the flexor tendons to that digit. The extremities of this arch are attached to the sides of the first phalanx near its base, where they become continuous with the flexor sheaths. In addition each process is connected with the transverse metacarpal ligament. These four digital processes are all bound together by the transverse palmar ligament, which stretches across the palm on a level with the heads of the metacarpal bones. The fascia lies immediately subjacent to, and closely connected with the thick skin of the palm.

Dupuytern's contraction consists in the shortening of the fascia and especially of the digital processes. All the processes may be, but the inner two usually are the ones affected. It is on account of the contraction of these bands that division of the palmar fascia is most often performed. The division may be performed by the sub-cutaneous or the open method.

Operations.—1. *The Sub-cutaneous Operation.*—This is performed in the same way as in division of the plantar fascia of the sole of the foot.

A fine tenotome is introduced between the skin and the fascia, the blade being on the flat. The edge is then turned towards the deep structures of the palm, and the band of fascia it is wished to

divide is brought against the sharp edge by extending the finger. Care must be taken that the blade does not pass deeply into the palm for fear of wounding the digital vessels and nerves. Multiple punctures are necessary to divide the several bands sufficiently. Special care is needed of the vessels and nerves near the sides of the roots of the fingers. Points of division are chosen, if possible, where the skin and fascia are not firmly united to each other. The fingers are at once put up in splints in a fully extended position, and kept extended for some weeks, being allowed free movements each day after the first week. If they are not taken down and moved systematically each day the fingers will very shortly become stiff.

2. *The Open Method.*—A tourniquet is applied to the arm. A longitudinal incision is made down the palm over the middle of the contracted portion of fascia, and the skin retracted. If needed, two small transverse incisions may be added, one at each end of the first incision. The two flaps thus marked are then reflected. The thickened fascia is now dissected from off the deeper structures beginning at the proximal end and working towards the fingers, care being taken not to damage the digital vessels and nerves. The more complete the dissection is the more certain is the result. As much, therefore, of the fascia as seems at all thickened or tense is removed. The tourniquet is then taken off and all bleeding points secured. The skin flaps are replaced and the hand put up in a splint with the affected fingers in the extended position. The fingers are passively moved after the third day.

Comment.—The open operation is the more severe of the two. The chief points which warrant its use are strict asepsis, free removal of the fascia, and accurate suturing of the skin flaps to secure rapid healing. The flaps of the thick skin of the palm are easy to buttonhole when dissecting them off the fascia, and they are very liable to inturn at the line of suture. The great advantages of the open method are that the surgeon sees accurately what he is dividing, the comparatively short period of after-treatment, and the condition being far less likely to recur than when the subcutaneous method is followed.

Operations for the Union, Lengthening and Shortening of Tendons

The name " tenorraphy " is given to operations which have as their aim the union of the divided ends of tendons.

When a tendon is divided the end attached to the muscular belly is at once retracted into the tendon sheath so that a

considerable gap remains between the two ends. If the tendon is united at once or shortly after division, as at the end of an operation in which it has been previously divided, this is called primary union. If some time has elapsed and a second operation is necessary to expose and suture the ends, this is termed secondary union.

It is often extremely difficult to find both ends of a tendon which has been divided as the result of an accident. The distal end is usually found with ease, but the proximal end, owing to the contraction of the fleshy belly, is withdrawn into the tendon-sheath for a considerable distance. It is therefore often necessary to enlarge the wound in a proximal direction, and to slit up the tendon sheath. Strict asepsis must be carefully attended to in carrying out this operation not only for the fear of the spread of septic mischief, which may easily travel up the tendon sheath, but also owing to the fact that tendons which are relatively evascular structures are very liable to slough if sepsis gain access to them. If the tendon has already passed across a joint on the proximal side of the division this joint should be placed in such a position as to bring the two ends together, as, for example, if an extensor tendon was divided on the back of the hand, the wrist joint should be extended as far as possible while the proximal end of the tendon is being sought for, and even flexion of the elbow might help in such a case. Another plan in such a case is to flex the fingers strongly so as to pull down the extensor tendon, which is divided by those tendons which still remain intact. A third method is to bandage the limb tightly from above downwards so as to squeeze the retracted tendon down into the wound. The two ends, when found, are grasped with forceps, and the suturing proceeded with in one of the ways described below.

In performing primary suture of tendons the ends need not be refreshed unless ragged or damaged. In secondary suture it is best to refresh the ends, removing as little as possible in so doing.

1. *Where the Ends can be placed in Apposition*

A. When the tendon is round and of medium or large size, a fine needle threaded with thin silk is passed from before backwards through one end and from behind forwards through the other. Two or more sutures may thus be passed according to the size of the tendon. These are merely tension sutures, and should be passed through the tendon at least half an inch from the end, when they are *in situ* they are tightened up so as to bring the two

ends of the tendon into apposition without overlapping. If the suture is passed as directed, the knot will be on the superficial surface of the tendon. Smaller sutures should then be inserted to keep the ends in good apposition.

B. When the tendon is thin and flat, as in the case of the extensors of the fingers, it is advisable to use Wölfler's method of suturing, as there is a great tendency for the stitches to cut out from the parallel fibres of the tendon. In this method the needle, threaded with silk, is made to traverse the distal portion of the tendon from before backwards near one margin, then it is passed from behind forwards through the proximal end near the same margin. From here the suture passes across the front of the proximal end and pierces it from before backwards near the

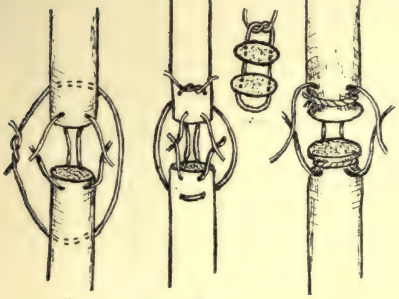


FIG. 194.—METHODS OF UNITING DIVIDED TENDONS.

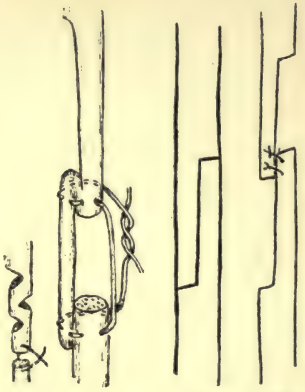


FIG. 195.—METHODS OF LENGTHENING TENDONS.

opposite margin. Lastly it pierces the distal end from behind forwards near the corresponding margin. The two ends of the suture are then tied across the front of the tendon and the two ends pulled into apposition. Small stitches may now be added if desired. A glance at Fig. 194 will better explain the proceeding.

C. When the tendon is round but too small for one of the two proceeding methods to be carried out without fear of the stitches being torn out, then Schwartz's method may serve. In this method a tight silk ligature is tied round each end of the tendon; the actual sutures are now inserted over these ligatures, which prevent cutting out.

D. Another excellent method for joining the ends of the tendon in position is to insert three silk sutures into each portion

of the tendon, knotting each suture, but leaving the ends long; the ends of the corresponding sutures can then be tied together.

2. *Where the Ends of the Tendon cannot be placed in Apposition*

In this case one of the following methods can be adopted to produce a junction between the two ends :—

A. Tendon lengthening by means of alternate transverse incisions, as in Fig. 195, A. These alternate incisions should include half the width of the tendon. When sufficient length has been obtained the two ends of the tendon can be united in one of the ways described above.

B. Tendon lengthening by turning down a flap, as in Fig. 195, B. In this method a portion of the proximal end of the tendon is turned down as a flap and sutured to the distal end. Care must be taken that the flap is not torn completely off the proximal end; this can be prevented by the introduction of a suture binding the two together.

C. Tendon lengthening by a Z-shaped incision, Fig. 195, C and D. Here a longitudinal incision is made down the tendon, and then made to come out at opposite sides of the tendon. The ends of the tendon are then united. Any amount of increase can be obtained in this way.

D. Tendon implantation. Here the gap between the two ends is left unfilled, both ends of the tendon being implanted into a neighbouring tendon, so that when either muscle contracts the distal portions of both tendons are drawn upon.

E. *Tendon Grafting* (*Tenoplasty*).—Here the gap between the severed ends is filled up with a tendon from a recently killed animal, the graft being sutured to the separate ends.

INSTRUMENTS USED FOR SURGICAL OPERATIONS

INSTRUMENTS WHICH ARE NEEDED FOR LIGATURE OF ARTERIES AND WHICH SHOULD BE PROVIDED FOR MOST OTHER OPERATIONS.

FIG. 196.—SCALPEL: BACK-POINTED BLADES.

FIGS. 197 and 198.—SCALPEL: MIDDLE-POINTED BLADES. (The smaller size suitable for amputating fingers.)

FIG. 199.—SPENCER WELLS' ARTERY FORCEPS.

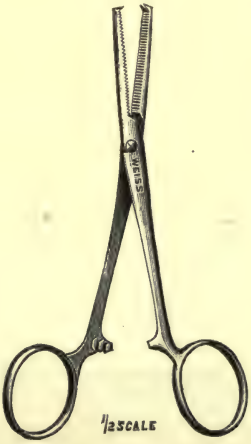


FIG. 200.—KOCHER'S ARTERY FORCEPS.

FIG. 201.—DISSECTING FORCEPS.

FIG. 202.—SINUS FORCEPS.

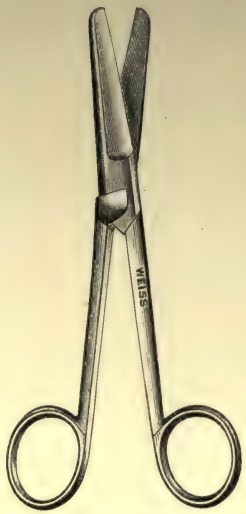


FIG. 203.—SCISSORS.

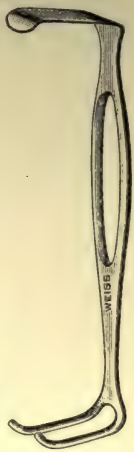
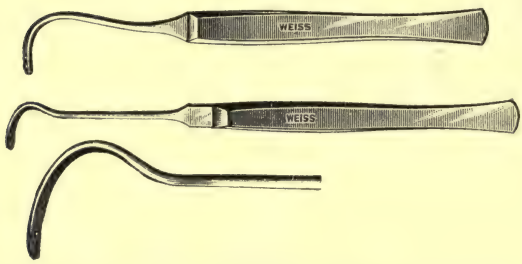


FIG. 204.—RETRACTORS.

FIG. 205.—BLUNT HOOKS.



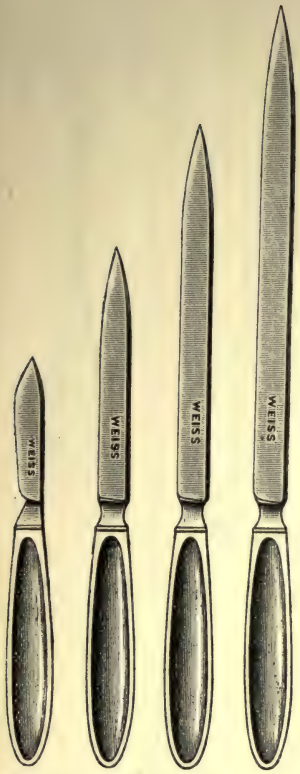
FIGS. 206 and 207.—ANEURISM NEEDLES. Suture and Ligature materials are not illustrated.

SPECIAL INSTRUMENTS FOR TENOTOMY.

FIG. 208.—SHARP TENOTOME.

FIG. 209.—BLUNT TENOTOME.

SPECIAL INSTRUMENTS FOR BONE OPERATIONS



FIGS. 210, 211, 212, and 213.—AMPUTATING KNIVES. (The largest knife shown in this series is seldom used now-a-days, and is inserted more for comparison than anything else, though in former days blades two to three inches longer were in frequent use. With one of the smaller knives the skin flaps are marked out; if the muscles are cut by transfixion, these knives, being middle-pointed, are admirably suited for the purpose. Even in circular amputations a blade longer than six inches is not a necessity. Figs. 210 and 211 are the sizes most frequently used; the former is a Syme's knife.)

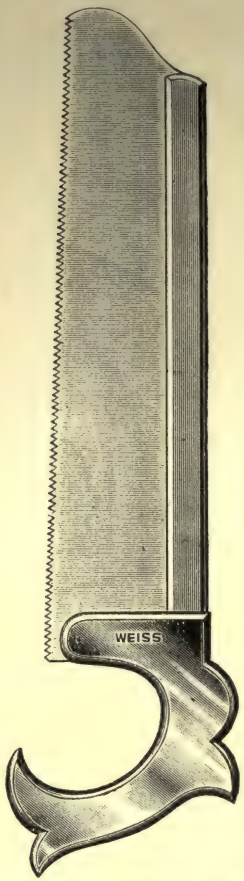


FIG. 214.—AMPUTATING SAW.

FIG. 215.—SMALLER AMPUTATING SAW.

FIG. 216.—METACARPAL SAW, FOR THE AMPUTATION OF THE DIGITS.

SPECIAL INSTRUMENTS FOR OSTEOTOMIES, RESECTIONS AND EXCISIONS

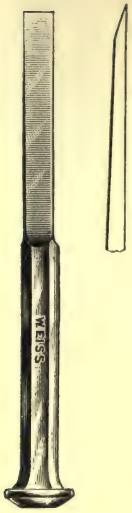


FIG. 217.—CHISEL. (And side View.)

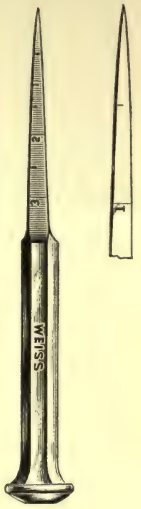


FIG. 218.—OSTEOTOME. (And side View.)

FIG. 219.—GOUGE.

FIG. 220.—MALLET.

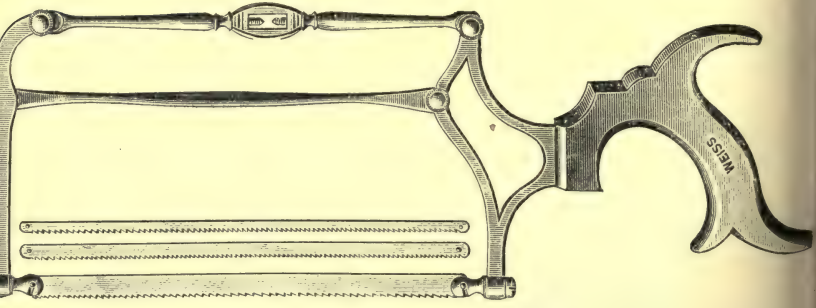


FIG. 221.—BUTCHER'S SAW.

FIG. 222.—ADAMS' SAW.

FIG. 223.—KEY-HOLE SAW (used for dividing bones of the face).

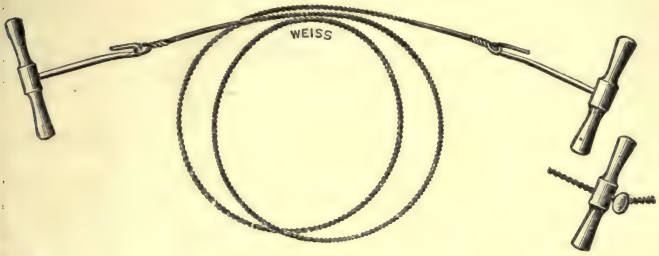


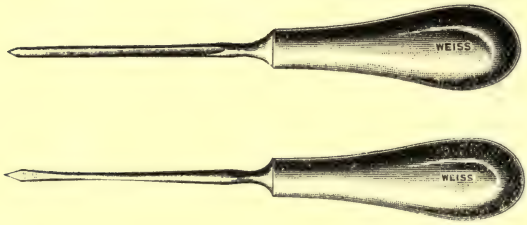
FIG. 224.—GIGILI'S WIRE SAW.

FIG. 225.—BONE FORCEPS.

FIG. 226.—SEQUESTRUM FORCEPS.

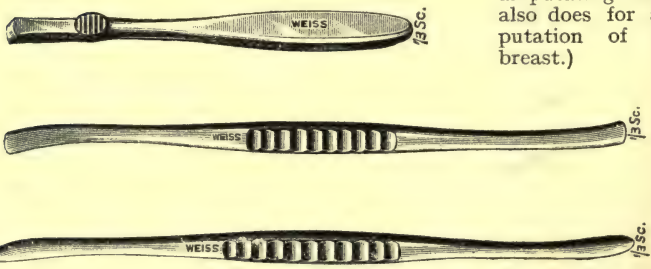
FIG. 227.—LION FORCEPS (Fergusson's).

FIG. 228.—WIRE CUTTERS.



FIGS. 229 and 230.—AWLS FOR DRILLING BONE.

FIG. 231.—RESECTION KNIFE. (Similar to Symes' amputating knife; also does for amputation of the breast.)



FIGS. 232, 233, and 234.—PERIOSTEAL ELEVATORS AND RASPATORIES OF DIFFERENT PATTERNS.

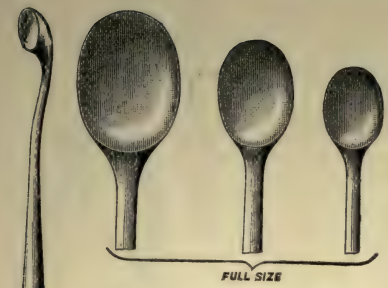


FIG. 235.—SHARP SPOONS.

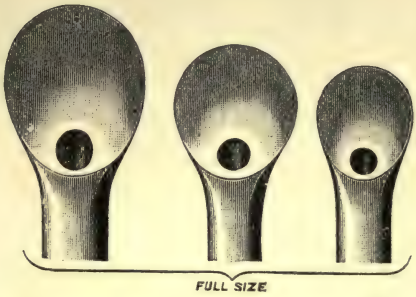


FIG. 236.—FLUSHING GOUGE (Barker's).

HEAD INSTRUMENTS

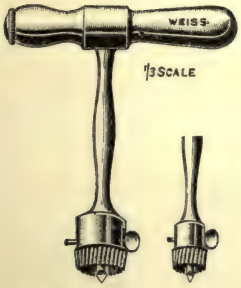


FIG. 237.—MODERN TREPHINE.

FIG. 238.—OLD-FASHIONED TREPHINE.

FIG. 239.—ELEVATOR FOR LIFTING TREPHINE DISC.

FIG. 240.—HEY'S SAW FOR DEPRESSED FRACTURES.

FIG. 241.—FORCEPS FOR BITING AWAY THE SKULL.

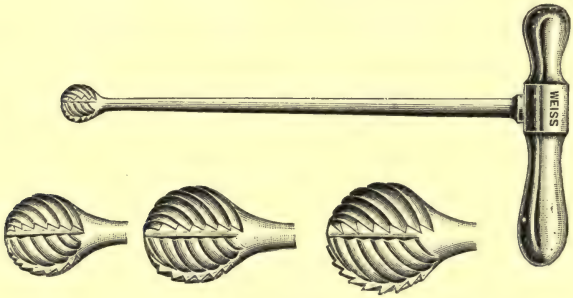


FIG. 242.—BURRS FOR EXPOSING THE MASTOID.

INTESTINAL INSTRUMENTS

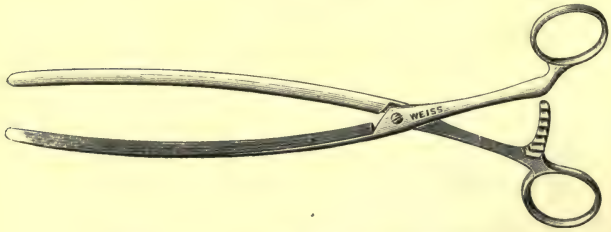


FIG. 243.—CLAMP (Clayton Green's).

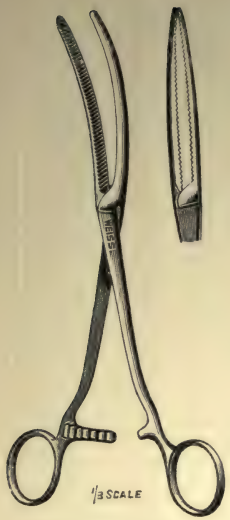


FIG. 244.—CLAMP (Doyen's).

FIG. 245.—CLAMP (Lane's).

FIG. 247.—HERNIA KNIFE.

FIG. 246.—HERNIA DIRECTOR.

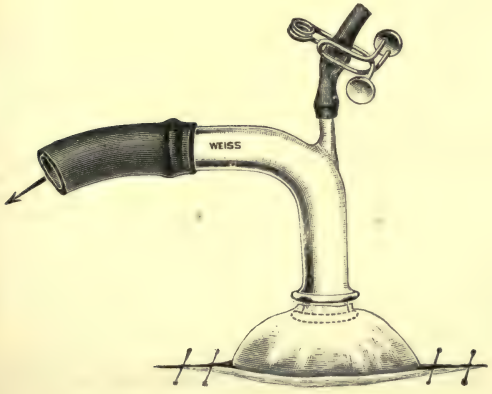


FIG. 248.—AUTHOR'S FLUSHING COLOTOMY TUBE.

FIG. 249.—AUTHOR'S FLUSHING COLOTOMY TUBE.

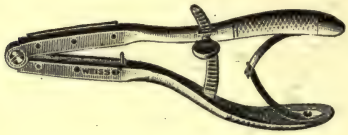


FIG. 250.—MODERN PILE CLAMP.

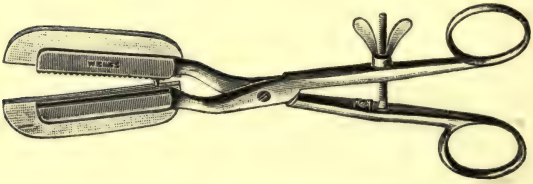


FIG. 251.—OLD-FASHIONED PILE CLAMP.

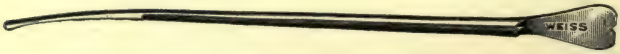


FIG. 252.—FLEXIBLE PROBES, POINTED DIRECTOR FOR FISTULA.

URINARY INSTRUMENTS

FIG. 253.—RUBBER CATHETER.

FIG. 254.—METAL CATHETER.

FIG. 255.—METAL PROSTATIC CATHETER.

FIG. 256.—GUM ELASTIC PROSTATIC CATHETER.

FIG. 257.—BICOUDE PROSTATIC CATHETER.

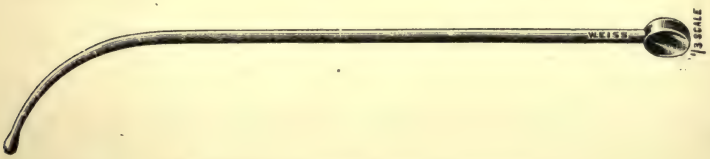


FIG. 258.—LISTER'S METAL BOUGIE.

FIG. 259.—GUM ELASTIC BOUGIE.

FIG. 260.—WHIP BOUGIE.

FIG. 261.—SOUND.

FIG. 262.—CHESELDON'S STAFF.

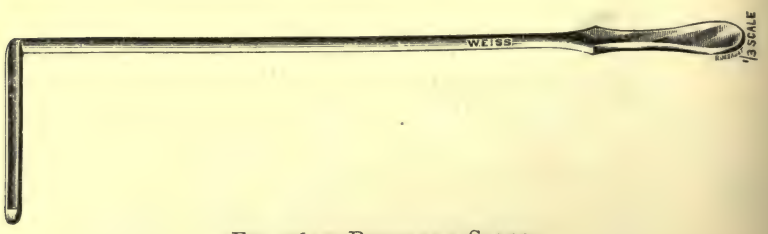


FIG. 263.—BUCHANAN STAFF.

FIG. 264.—SYME'S STAFF.

FIG. 265.—WHEELHOUSE'S STAFF.

FIG. 266.—URETHROTOME (Maisonneuve).

FIG. 267.—URETHROTOME (Thomson's).

FIG. 268.—TEALE'S GORGET.

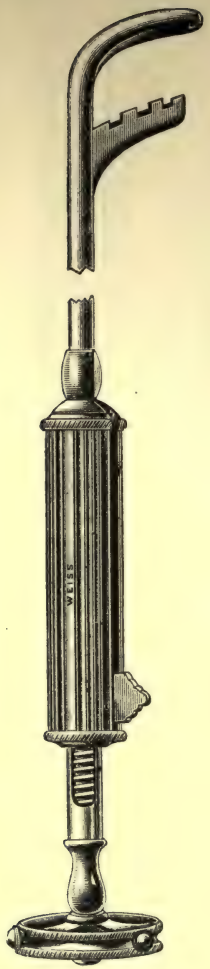


FIG. 269.—LITHOTRITE.

FIG. 270.—EVACUATOR.

FIG. 271.—EVACUATING CATHETER, TO FIT ON EVACUATOR (270).

MISCELLANEOUS INSTRUMENTS

FIG. 272.—O'DWYER'S GAG.

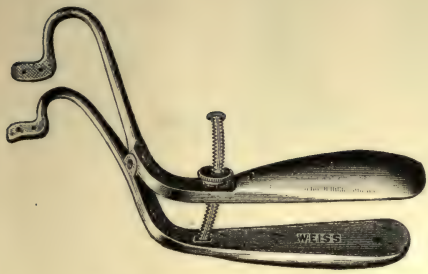


FIG. 273.—MASON'S GAG.

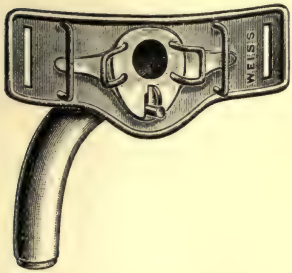
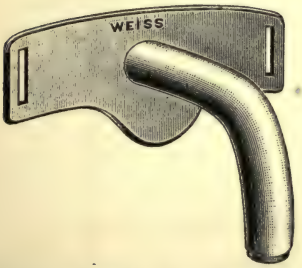


FIG. 274.—HANDLED NEEDLES FOR CLEFT PALATE.



FIGS. 275 and 276.—TRACHEOTOMY TUBE.

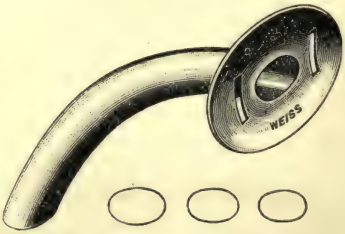


FIG. 277.—LARYNGOTOMY TUBE.

FIG. 278.—TRACHEA DILATOR.

FIG. 279.—MALGAINE'S HOOKS.

FIG. 280.—TROCHAR AND CANNULA.

FIG. 281.—KOCHER'S DISSECTOR.

FIG. 282.—VULCELLUM.

FIG. 283.—THEIRSCH'S SKIN-GRAFTING KNIFE.

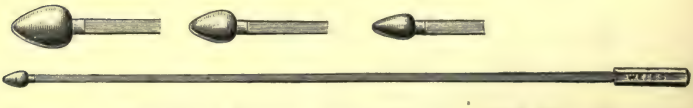


FIG. 284.—FLEXIBLE PROBES FOR EXPLORING THE BILE PASSAGE.

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THE END

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